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## (54) Laminograph and inspection and repair device using the same.

(57) A laminograph including, a radiation source for generating radiation towards a subject, a radiation surface sensor device with a two-dimensional resolution, fitted opposite to the radiation source for detecting the radiation from the radiation source which has passed through the subject, a scanning device for moving the subject to take a plurality of different positions between the radiation source and the radiation surface sensor device and for scanning the subject in each of the different positions by the radiation from the radiation source. The laminograph further includes a data collection device for collecting the plurality of outputs of the radiation surface sensor device during the scanning by the scanning device to obtain the plurality of radiographic images of the subject in the different positions, a position measurement device for measuring multiple positions of a focal plane at multiple places of the subject, a displacement measurement device for measuring multiple displacement based on the multiple positions of the focal plane measured by the position measurement device, and an image processing device for adding and averaging the plurality of radiographic images with the displacements to obtain a radiographic image of the subject focused on the focal plane as a tomographic image of the subject.

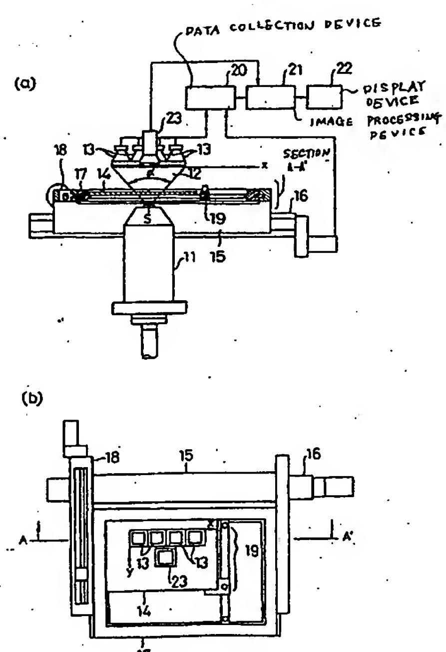

FIG. 1

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ing amount ΔS is determined according to the distance to the required layer section from the focal point of X-ray tube 391.

It is necessary to carry out the inspection using an enlarged radiographic image in order to improve the resolution in the inspection of electronic parts such as PWBs. In the case of using the laminograph this may be a partially enlarged laminogram. In case of inspecting the subject with a large area, such as a PWB, some of the parts mounted on the subject are enlarged and inspected, which makes an overall assessment difficult. It is also necessary to repair the faulty part, but it is difficult to transmit the inspection results to the repair line. Previously, a hard copy of the image or notes of handwriting have been used. For important cases, it is necessary to keep the documents of the inspection results for many years but storage is not easy.

## SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a laminograph which is capable of focusing precisely on the desired plane of a subject.

Another object of this invention is to provide a laminograph with improved S/N ratio in the tomographic image to be obtained.

Still another object of this invention is to provide a laminograph which can efficiently control the inspection position of a subject with a comparatively large inspection area and can inspect the subject with certainty.

Another object of this invention is to provide an inspection and repair device which can efficiently control the inspection position of a subject with a comparatively large inspection area and can inspect and repair the subject with certainty.

These and other objects of this invention can be achieved by providing a laminograph, including, a radiation source for generating radiation towards a subject, a radiation surface sensor device with a two-dimensional resolution, fitted opposite to the radiation source for detecting the radiation from the radiation source which has passed through the subject, a scanning device for moving the subject to take a plurality of different positions between the radiation source and the radiation surface sensor device and for scanning the subject in each of the different positions by the radiation from the radiation source. The laminograph further includes a data collection device for collecting the plurality of outputs of the radiation surface sensor device during the scanning by the scanning device to obtain the plurality of radiographic images of the subject in the different positions, a position measurement device for measuring multiple positions of a focal plane at multiple places of the subject, a displacement measurement device for measuring multiple displacements based on the multiple positions of the focal plane measured by the position measurement device, and an image processing device for adding and averaging the plurality of radiographic images with the displacements to obtain a radiographic image of the subject focused on the focal plane as a tomographic image of the subject.

According to one aspect of this invention, there is provided a laminograph including, a radiation source for generating radiation towards a subject, a radiation surface sensor device, with a two-dimensional resolution, fitted opposite to the radiation source for detecting the radiation from the radiation source which has passed through the subject, a scanning device for moving the subject to take a plurality of different positions between the radiation source and the radiation surface sensor device and for scanning the subject in each of the different positions by the radiation from the radiation source. The laminograph further includes a data collection device for collecting the plurality of outputs of the radiation surface sensor device during the scanning by the scanning device to obtain the plurality of radiographic images of the subject in the different positions, a displacement determining device for determining multiple displacements at multiple places of the subject based on a pattern on the radiographic images, and an image processing device for adding and averaging the plurality of radiographic images with the displacements to obtain a radiographic image of the subject focused on a single focal plane as a tomographic image of the subject.

According to another aspect of this invention, there is provided a laminograph including, a radiation source for generating radiation towards a subject, a radiation surface sensor device, with a two-dimensional resolution, fitted opposite to the radiation source for detecting the radiation from the radiation source which has passed through the subject, a scanning device for moving the subject to take a plurality of different positions between the radiation source and the radiation surface sensor device and for scanning the subject in each of the different positions by the radiation from the radiation source. The laminograph further includes a data collection device for collecting the plurality of outputs of the radiation surface sensor device during the scanning by the scanning device to obtain the plurality of radiographic images of the subject in the different positions, an image pre-processing device for processing one of enhancing, weakening and deleteing characteristics of the radiographic images to obtain pre-processed radiographic images, and a laminograph image restoration device for restoring a tomographic image of a desired plane from the pre-processed radiographic images and an information for a transmission direction of the radiation, whereby to improve the S/N ratio of the tomographic

Figure 15 is a view showing a sixth embodiment of a laminograph according to this invention;
Figure 16 is a view showing a seventh embodiment of a laminograph according to this invention;
Figure 17 is a view showing the structure of the distance measuring device using the image matching method as one example of the contrast and triangulation methods;
Figure 18 is a view showing an eighth embodiment of a laminograph according to this invention;
Figure 19 is a view given in explanation of the operations of the laminograph shown in Figure 18:
Figure 20 is a view showing the structure of a ninth embodiment of a laminograph according to this invention;
Figure 21 is a view showing the board which is the subject used in the laminograph shown in Figure 20;
Figure 22 is a view given in explanation of the operations of the laminograph shown in Figure 20;
Figure 23 is a view given in explanation of the operations of the laminograph shown in Figure 20;
Figure 24 is a view given in explanation of the operations of the laminograph shown in Figure 20;
Figure 25 is a view given in explanation of the operations of a tenth embodiment of a laminograph according to the invention;
Figure 26 is a view given in explanation of the operations of the laminograph shown in Figure 25;
Figure 27 is a view showing an eleventh embodiment of a laminograph according to this invention;
Figure 28 is a view given in explanation of the operations of the laminograph shown in Figure 27;
Figure 29 is a view given in explanation of the operations of the laminograph shown in Figure 27:
Figure 30 is a view given in explanation of the operations of a twelfth embodiment of a laminograph according to this invention;
Figure 31 is a view given in explanation of the operations of the laminograph shown in Figure 30;
Figure 32 is a block diagram showing the structure of a thirteenth embodiment of a laminograph according to this invention;
Figure 33 is a flow chart showing the operations of the laminograph shown in Figure 32;
Figure 34 is a flow chart showing the processes using a shape filter as pre-processes in the laminograph shown in Figure 32;
Figure 35 is a flow chart showing the processes using a spatial filter as pre-processes in the laminograph shown in Figure 32;
Figure 36 is a flow chart showing the operations of the laminograph shown in Figure 32;
Figure 37 is a view showing the image display processing device (lamino image processing device) used in the processes shown in Figure 36;
Figure 38 is a view showing the three-dimensional display in the laminograph shown in Figure 32;
Figure 39 is a view showing a display with a specified section enhanced in the three-dimensional display in the laminograph shown in Figure 32;
Figure 40 is a view given in explanation of the display of fixed pitch added images in a fourteenth embodiment of a laminograph according to this invention;
Figure 41 is a view showing extraction and deletion of specific images in a fifteenth embodiment of a laminograph according to this invention;
Figure 42 is a flow chart showing the processes of extraction and deletion of specific Images shown in Figure 41;
Figure 43 is a block diagram showing the structure of another embodiment of a laminograph according to this invention;
Figure 44 is a view showing the repair device used in the laminograph shown in Figure 43;
Figure 45 is a view showing the form of the image displayed on the display;
Figure 46 is a flow chart showing the operations of the laminograph shown in Figure 43;
Figure 47 is a flow chart showing the method of matching the reduced scale of CAD pattern and the radiographic image;
Figure 48 is a flow chart showing the image display sequence;
Figure 49 is a view given in explanation of the correlation with the repair line;
Figure 50 is a flow chart showing the processes for displaying a fault position;
Figure 51 is a flow chart showing the flow of the X-ray inspection and repair processes;
Figure 52 is a view showing a laminograph of the prior art;
Figure 53 is a view showing another laminograph of the prior art; and
Figure 54 is a view showing the structure and functions of still another laminograph of the prior art.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts

radiographic images, i.e. the tomographic images, of inspection areas 26a - 26f, are produced sequentially by image processing device 21. The positions of these scanned areas A1 - A4 and inspection areas 26a - 26f are described by X-Y coordinates with their starting points at one end of board 14 and memorized in advance in a mechanism control device (not shown) for each type of board. So, it is possible to obtain a tomographic images of inspection areas simply by the operator specifying the type of the board to be inspected.

Figure 5 show a section of board 14. In this figure, 24 is an IC, 25 are soldered parts, and surface 14a of board 14 is the focal plane. It is necessary to focus on surface 14a of the front surface in order to examine the soldered parts 25 of the front surface of board 14 of this structure, without being obstructed by parts of the front or reverse sides of board 14. When board 14 is curved the focal spot meets only a single focal plane, so it is impossible to focus simultaneously on the soldered parts in all the inspection areas 26a - 26f shown in Figure 4. Thus, in this embodiment, a tomographic image is produced by setting an individual focal plane for each inspection area, which is a feature of this invention. For this purpose, four distance measurement positions Q are set in the respective corners of each of inspection areas 26a - 26f as shown in Figure 4.

Because of this, before scanning, distance measurement device 23 is used to measure distance d between the distance measurement datum plane and surface 14a of board 14 at distance measurement position Q set in each corner of the inspection areas. On the basis of this distance d, calculations are made with Equation (2), as detailed above, to find distance L between surface 14a of board 14 and X-ray focal spot S in each inspection area, and the focal plane is set separately for each inspection area by this.

The position of distance measurement position Q is selected to be a position where a surface pattern is visible without parts, and it is stored in memory beforehand by the mechanism control device along with the inspection area positions of each type of board. Also the values of distances d are supplied from distance measurement device 23 to image processing device 21 and, for example, the values d for the four corners Q of each inspection area are averaged and the distance thus averaged is used for each inspection area.

Next the operation of the preparation of a tomographic image for one inspection area, for example 26a, by image processing device 21 are described with reference to Figures 6 and 7.

First, as shown in Figure 6, board 14 is moved in axial direction x (with P as an extent of this movement). Radiographic image is collected each time there is a change in extent of movement $\Delta P$ and all these radiographic images are stored in the memory of image processing device 21. When radiographic images at each change in range of movement $\Delta P$ are collected, the projection points on the detection surface of detector 13 of the points on the focal plane, i.e. surface 14a of board 14, are displaced by $\Delta P'$ each time, as shown in Figure 6. The change in movement $\Delta P'$ can be calculated by the following equation (3).

$$\Delta P' = \Delta P \times FDD/L = \Delta P \times FDD/(a - d) \quad (3)$$

In this equation (3), L is distance between surface 14a of board 14 and X-ray focal spot S of X-ray tube 11 and FDD is a distance between X-ray focal spot S and the detection surface of detector 13. According, $\Delta P'$ is a function of distance d detected by distance measurement detector 23.

Next, as shown in Figure 7, the multiple radiographic images obtained by X-ray detectors 13 at the same movement position P are arranged on plane xy at the same distance from each other as the distance between X-ray detectors 13 to form as one combined image. At each change in range of movement $\Delta P$, multiple combined images are arranged in the direction of P as shown in Figure 7. Then multiple combined images are added and averaged with the displacement $\Delta P'$ along axial direction x each other (including linear interpolation calculations). As, by doing this, the points on the focal plane all overlap each other at the same position and they are emphasized, and whereas points not on the focal plane overlap at some distance from each other and are thus vague and blurred.

Thus it is possible to obtain a radiographic image which is focused on a single focal plane parallel to the detection surface, that is, a tomographic image. The image data before adding and averaging are all accumulated in the memory and it is thus possible to prepare a tomographic image on any focal plane by changing $\Delta P'$, without collecting data again.

The focal plane position for taking a tomographic image can be set slightly higher (or lower) than upper surface 14a (or lower surface) of board 14 by applying micro-correction terms to $\Delta P'$. It is thus possible to focus on the solder by taking the solder thickness into account. It is also possible to perform correction of errors generated systematically in distance measurement including such errors in setting the distance measurement datum plane. The focal plane position can be aligned with internal layer pattern positions used for pattern inspection as well with the solder position. In such cases, if the thickness from the surface to the internal layer is $\Delta L$, then $\Delta P'$ should be calculated by using $(L - \Delta L)$ in place of L in equation (3).

Thus, in this embodiment of the invention, even if board 14 is curved, a tomographic image is obtained automatically in which the focal spot coincides with the inspection plane. It is possible to obtain a tomographic image focused on the inspection plane without adjustment, even when the thickness of the board is changed, the position of the inspection plane is shifted, or board clamp 19 is poorly fixed so that the inspection plane

In this third embodiment, it is possible to scan radiographic image collection along with the measurement of the surface height, and thus it is possible to shorten the inspection time.

Figures 12 and 13 show a fourth embodiment of a laminograph according to this invention. As shown in Figure 12, in this fourth embodiment, an X-ray tube 61 which has an X-ray focal spot S and a detector 63 that is an X-ray plane sensor, face each other with a board 64 which is a subject between them and both of them revolve in synchronism around an axis of rotation 66. In Figure 12, 62 is an X-ray beam output from X-ray tube 61.

Figure 13 shows the structure of the fourth example of the laminograph shown in Figure 12. As shown in this figure, X-ray tube 61 is rotated around axis of rotation 66 by a source rotating mechanism 67, and X-ray beam 62 generated from X-ray tube 61 passes through board 64 which is the subject, and is detected by detector 63. Detector 63 is revolved around axis of rotation 66 by a detector revolution and rotation mechanism 68 and is also rotated on the orbiting frame by mechanism 68 so that it revolves without changing its azimuth. The rotation of X-ray tube 61 and the revolution of detector 63 are linked by gears (not shown) and thus synchronized.

Board 64 which is the subject, is supported by an X, Y, Z table 70. A distance measurement device 69 is fitted on axis of rotation 66 so that it measures the surface position of board 64.

X-ray tube 61 is connected to a source rotating mechanism 67 by a source shift mechanism 71 so that it can be shifted in the direction to detector 63. This source shift mechanism 71 is used to vary the magnification of the tomographic image.

In the fourth embodiment structured as described above, board 64 which is the subject, is moved in axial direction X, Y such that a distance measuring position in or near the inspection area is set in the center, and then the distance is measured by distance measuring device 69. According to this, board 64 is moved in axial direction z to bring the surface of the board 64 to the focal position. Then, board 64 is moved in horizontal direction X, Y so that the inspection area is in the center.

In this state, X-rays are projected from X-ray tube 61 while X-ray tube 61 and detector 63 are rotated, and X-ray radiographic images of the board are collected. The radiographic images thus collected are added and averaged (in this embodiment displacement is unnecessary), and a radiographic image focused on board 64, i.e. a tomographic image, is obtained. It is also possible to focus on a plane which is displaced by $\Delta Z$ on the basis of the surface of board 64 by adding an offset $\Delta Z$ in the above-described movement in axial direction Z.

In the above description, board 64 which is the subject, is displaced in axial direction Z, and the curve of board 64 is corrected to focus on the board surface. But movement in direction Z can be omitted. In such case, "displacement" is calculated from data from distance measurement device 69, and a tomographic image is obtained by adding and averaging the radiographic images while they are displaced as in the first embodiment.

In addition to the advantages seen in the first embodiment, when movement in axial direction Z is applied, this fourth embodiment does not require displacement of the images and only adding and averaging processing is performed. It thus has the advantages that the laminograph is economical in cost and the processing speed is quick. It is also possible to vary the magnification of the tomographic image using source shift mechanism 71. In such cases, the magnification alone can be changed, without changing the position of the focal plane, by making the shift direction the direction shown in Figure 13.

Figure 14 shows the essential parts of a fifth embodiment of a laminograph according to this invention. This fifth embodiment is only different from the fourth embodiment as shown in Figures 12 and 13, in that it has a source rotating mechanism 72 which rotates X-ray tube 61 around an axis which passes through X-ray focal spot S of X-ray tube 61.

This fifth embodiment (also first to fourth embodiments) has a high voltage cable 73 to connect X-ray tube 61, as shown in Figure 14 to the X-ray control device (not shown in this figure). When X-ray tube 61 is rotated around axis of rotation 66, X-ray tube 61 is rotated in the opposite direction in synchronization by source rotation mechanism 72. High voltage cable 73 can thus be rotated many times in one direction without becoming twisted. Also, in comparison with the fixed type, no excessive force is exerted on the thick and bend-resistant high voltage cable 73 and its life is thus extended, and thus the cable accommodation space need only be small.

Figure 15 shows a sixth embodiment of a laminograph according to this invention. In Figures (a) and (b), an X-ray tube 1 which is the radiation source, and a detector 3 which is the radiation plane sensor, are constructed so as to move in synchronization in a curved motion and a straight motion, respectively. In the scanning method achieved by these structures, it is possible to adjust the focus in a similar way as in the fourth embodiment. In Figure 15, 4 is a subject and 5 is a distance measurement device.

Figure 16 shows a seventh embodiment of a laminograph according to this invention. In these figures (a) and (b); subject 4 and sensor 3 which is the radiation plane sensor are constructed so as to rotate in synchronization in each axis which is parallel to each other. In the scanning method performed by these structures, It is possible to adjust the focus in a similar way as in the fourth embodiment.

large subjects.

Also as a television image pickup tube is sensitive to X-rays, it may be used as a radiation plane sensor. In such cases, distortion correction is also necessary. The detection surface of a pickup tube is small and a pickup tube is of high resolution, but the detection efficiency declines for high energy X-rays, it is not preferable in such cases. Therefore a pickup tube is effective when used for high precision examination of a small subject through which X-rays travel with relative ease.

A combination of a fluorescent sheet and a television camera may also be used as a radiation plane sensor. In this case, a detection surface larger than that of the X-ray I.I. may be obtained. Any other radiation plane sensors with two-dimensional resolution may be used, in any form.

Inspection of soldering of surface mounted board is performed by the embodiments described above. But this invention is not limited to inspect such soldering. The laminograph according to this invention may be used, for example, for inspection of the internal patterns of multilayer boards, interior faults of electronic parts, dimension inspection and airport baggage inspection.

Figure 18 shows an eighth embodiment of a laminograph according to this invention. In embodiments of the laminograph described above, the distance to surface 14a of board 14, which is the focal plane is measured using a distance measurement device, and a focal plane is focused on at a distance based on this measured distance. By contrast, in this embodiment, focusing is made by a pattern on the radiographic image. This pattern may be, for example, a wiring pattern, soldering patter or board pattern which has been obtained beforehand as set data.

In Figure 18, a radiation beam 52 which is emitted from a radiation focal spot S of a radiation source 51 passes through a subject 54 and is detected by radiation plane sensors 53. As also shown in this figure, a plane xy is set as the measurement plane. In the figure, the letter "A" is written on the front surface and "B" on the rear surface of subject 54. Subject 54 is moved parallel to axial direction x by a scanning means (not shown), and the radiographic image of subject 54 is obtained by radiation surface sensor 53 and data collection device (not shown) at equal scanning distances. An image processing device (not shown) differentiates and "converts to binary image" (hereinafter is written as "digitizes") the radiographic images and then displaces them along direction x to take their correlations with a standard image. A correlation value I becomes large at the position at which the patterns match.

Thus, as shown in Figure 19, the radiographic images differentiated and digitized in the image processing device are displaced along direction x and are correlated with the standard image. Two peaks appear in correlation values I at two degrees of displacement, u1 and u2, in two cases, when there is a match with pattern "A" on the front surface of subject 54 and when there is a match with pattern "B" on the reverse surface of subject 54.

When subject 54 is a two-layer board with pattern "A" on the front surface and pattern "B" on the reverse surface, the front surface which is nearer to radiation source 51 forms a peak at a larger displacement u1 and the reverse surface which is further away forms a peak at a smaller displacement u2. Therefore, when it is wished to focus on pattern A on the front surface, specification control is performed so that the peak with the larger degree of displacement ul is selected. The image processing device adds and average the radiographic images to the standard image by displacement u1 along direction x. By performing this process for all radiographic images, it is possible to obtain a tomographic image which is a radiographic image focused on the front surface of subject 54.

When, for example, subject 54 is a four-layer board, when correlations are taken as described above, four peaks u1, u2, u3 and u4 are formed. It is therefore possible to obtain a radiographic image focused on the desired layer by specifying which number of displacements from the largest one.

Figure 20 is a drawing showing the structure of a laminograph according to a ninth embodiment of this invention, and (a) and (b) show, respectively, a front view and a plan view of the laminograph. One part of Figure 20(a) shows a section along line A - A' in Figure 20(b).

In the laminograph shown in Figure 20, the structure is the same as that in the embodiment shown in Figure 1, except for the absence of distance measurement device 23. Detectors 13 used in the laminograph shown in Figure 20 is the same as that shown in Figure 3.

Below, the operations of the ninth embodiment of the invention is described with reference to Figures 21 - 24.

Figure 21 shows the same board 14 as that shown in Figure 4, except that the distance measurement positions are not particularly specified on board 14.

Board 14 shown in Figure 21 is moved by x movement mechanism 16 and y movement mechanism 18, the radiographic images of scanned areas A1 - A4 are obtained successively by data collection device 20 and tomographic images of inspection areas 26a - 26f are prepared successively by image processing device 21. The positions of these scanned areas A1 - A4 and inspection areas 26a - 26f are defined by coordinates X

justed).

In the embodiment described above, it is possible to focus on the inspection plane from the radiographic images only, and thereby to obtain a tomographic image focused on the inspection plane, without using any optical or mechanical means of measuring the position of the board plane or adjusting the board position.

Figure 25 shows the operation of a laminograph according to a tenth embodiment of this invention. The structure of the laminograph in this tenth embodiment is the same as that of the ninth embodiment shown in Figure 20.

In contrast to the ninth embodiment in which focusing is performed using the wiring pattern on the board, this tenth embodiment focuses using the solder pattern.

From the radiographic image shown in Figure 25(a), it is clear that the solder parts 25 are higher in density. This embodiment uses the high-density solder parts 25 to digitize these for producing the image shown in Figure 25(b). In Figure 25, 28 is a capacitor and 24a is the IC being inspected.

The wiring patterns are removed from the image shown in Figure 25(b) but the parts, such as capacitor 28 etc, strongly absorbed remain. Next, each link of parts with low digitized level (black in the figure) is labelled and the area of each label is found, using the histogram function of the image processing. The image shown in Figure 25(c) is obtained by removing the labelled part with the large area. Thus solder pattern only is obtained.

As shown in Figure 26, correlation is taken between images thus prepared in which sweeps $P = Po$ and $P = Po + N \cdot \Delta P$. Then displacement $\Delta P'$ is found in the same way as in the ninth embodiment. A tomographic image is obtained by subsequent processing in the same way as in the ninth embodiment.

In this embodiment, focusing is performed using the direct solder pattern, and focusing is possible without being influenced by the state of the circuit pattern and with few malfunctions. Also it is possible to omit differential processing and other time-consuming processes and thus to shorten the processing time.

In the tenth embodiment, as in the ninth embodiment, it is possible to improve statistical accuracy by finding $\Delta P'$ from multiple sets of radiographic images with different values of Po and N and averaging these. It is also possible to finely adjust the focal plane by applying micro-adjustment terms to $\Delta P'$. It is further possible to find correlations between these individual radiographic images and a standard image and thus find individual displacements by the correlations thus found.

Figure 27 shows an eleventh embodiment of a laminograph according to this invention. In this eleventh embodiment, an X-ray tube 81 with an X-ray focal spot S, and a detector 83 which is X-ray plane sensor, face each other with a board 84 that is the subject between them, and both of these are rotated in synchronism around an axis of rotation 86. In Figure 27, 82 is an X-ray beam output form X-ray tube 81.

In this embodiment, detector 83 which is X-ray plane sensor, is rotated around axis of rotation 86, on a plane of rotation which is parallel with the measurement plane shown as plane xy, maintaining its azimuth constant, and radiographic images of the subject are obtained during the rotating scan.

In this embodiment, as shown in Figure 28, the image processing means differentiates and digitizes the various radiographic images. With displacing them along axial direction x, y, it finds correlations between a standard radiographic image and them. Correlation value I becomes large when the pattern match. When there are two layers of patterns in board 84, peaks of correlation values I are formed at two places, at displacement u in axial direction x and displacement v in axial direction y: (u1, v1) and (u2, v2). The peak produced when displacement $(u2 + v2)^{1/2}$ is larger is due to the pattern of a layer close to X-ray tube 81 and the peak produced when this is smaller is due to the pattern of a layer further away.

In the embodiment shown in Figures 27 and 28, when pattern A of the upper layer of board 84 which is the subject is focused upon, the larger displacement (u1, v1) is selected. Radiographic image focused on upper layer A, that is a tomographic image, can be obtained by finding the displacement for each radiographic image in the same manner and by adding and averaging the radiographic images.

When radiographic image collection is performed for each time the rotation angle step is the same, there is no need for the above-described correlation to be found for all radiographic images. As shown in Figure 29, an $\alpha°$ image is taken as standard and correlations are found between this and an $(\alpha° + 180°)$ image which is separated from $\alpha°$ image by 180°, and the displacement (u1, v1) is then obtained. In subsequent processes, the displacement (u, v) can be found if a circle with the radius (0, 0) - (u1, V1) is drawn and it is assigned for each collection angle pitch, as shown in Figure 29.

Also, as in the ninth and tenth embodiments, it is possible to improve statistical accuracy by preparing sets of correlations, and by averaging them to find the displacement. It is also possible to make fine adjustments of the focal plane by slightly changing the radius of the displacement circle concentrically.

Figure 30 shows a twelfth embodiment of a laminograph according to this invention. The structure of the laminograph in this twelfth embodiment is the same as that of the ninth embodiment shown in Figure 20. In the ninth embodiment, displacement is found by finding correlation between radiographic images. But in the

When subject 113 moves all points of subject on a focal plane which is parallel to the ditection plane, shift on the radiographic image with same shift amount determined by the position of movement. Only information for the focal plane is accumulated by adding the radiographic images after the shift (displacement) is given to each radiographic image with said displacement, and this blurs other images.

Next, the operation of the laminograph shown in Figure 32 is described with reference to the flow-chart shown in Figure 33. In Figure 33, a radiographic image is collected (step 3310), this radiographic image is pre-processed (step 3320) and then lamino processing is carried out (steps 3380, 3390, 3395). The pre-processing in step 3320 consists of extracting areas with higher density D than a specified threshold value Dt from the radiographic image and digitizing these (step 3330). Then, the average density value of the entire image is calculated (step 3340), the density of the extracted areas is substituted by the average value Pd (step 3350), and a pre-processed image after completion of pre-processing is obtained (step 3370) by image composition (step 3360), i.e. Pd at extracted area and original image at not extracted area. This pre-processing is suitable for a tomographic image of a subject which is preknown to have no portions with large X-ray absorption on the focal plane so as the reduce the effect of portions with large X-ray absorption on other planes.

After completion of pre-processing, image shift (step 3380) and addition and averaging processing (step 3390) are performed on the pre-processed image, and a tomographic image on the focal plane is thus obtained (step 3395). This embodiment is effective in case when a low probability of a high density image being present on the focal plane is anticipated. When no prediction can be made concerning the quality of the image on the focal plane, the image data of the extracted areas is converted to the weighted average density. In step 3330, image areas are extracted having a larger density D than density threshold value Dt. But it may be preferable to extract areas whose density is less than Dt or whose density is in a density band, depending on the character of the image on the focal plane.

The above-described pre-processing is performed to improve the S/N ratio of the image on the focal plane. There are many kinds of other pre-processing.

Figure 34 shows an example of pre-processing wherein a shape filter is used and the process is principally carried out by shape filter part 614 in central control unit 116.

In the process shown in Figure 34, first, digitization (conversion to binary image) is carried out to extract the image on which shape-processing is to be performed (step 3410). Then, extracted area shape filtering is performed on this binary image (step 3420). In this process, the extracted areas are labelled (step 3430), and a subject of processing is confirmed. Next, the circularities Pxy of the extracted areas are measured (step 3440). Areas Pxy having a larger value of Pxy than the specified circularity threshold value is extracted (step 3450), and this extracted areas are density converted (step 3460) and composed (step 3470). The following processes are carried out as lamino processing on the pre-processed image thus subjected to addition processing (step 3480). For density conversion, density is converted to the average density value of the entire image or local points or the value of neighboring pixels, etc.

Figure 35 shows another example of pre-processing in which a spatial filter is used and this processing is mainly performed by spatial filter 615 in central control unit 116.

In the process seen in Figure 35(a), a filter function is used (step 3525) on the original images in the extracted areas by digitization (step 3510). Figure 35(b) shows one example of such a filter function 344. This performs masking processing with a 5 x 5 matrix. After the filtered images of the extracted areas and original image of other areas have been composed, this is taken as a pre-processed image (steps 3530 and 3540). The following processes are carried out as lamino processing on the pre-processed image.

The pre-processings described above are often more effective when used in combinations. An image processing means performs processes including image density processing, image shape processing, spatial frequency processing in desired areas, logic filtering, inter-image algorithms, morphological processing etc., which can emphasize, weaken or delete the characteristics of the radiographic image.

Pre-processed images are taken as regular radiographic images, and as shown in steps 3380 and 3390 of Figure 33 image shift and addition and averaging processing are performed and a tomographic image of the focal plane is obtained (step 3395). These processes are specified in advance and are automatically executed while incorporating radiographic images.

Next, the overall functions of the laminograph shown in Figure 32 are described. While subject 113 is moved by mechanism part 115, X-rays radiated from X-ray tube 111 pass through subject 113 and are acquired as radiographic images by X-ray data collection part 112, and radiographic images in many directions are thus obtained during this movement. The radiographic data is fed to image memory 608 of central control unit 116 via data I/O interface 607. The processing in which extracted area is cut out and the characteristic parameters of the shape are measured, and spatial filtering and other processings are performed by image processing part 610. Radiographic images are added with shifts according to the focal plane and averaged by addition and averaging part 609 to obtain a tomographic image on the desired focal plane which is parallel to the de-

without Hough transformation. It is thus possible to prevent display of incorrect information on the lamino image.

Below another embodiment of this invention is described with reference to figures.

Figure 43 is a block diagram showing the structure of one embodiment of a laminograph according to this invention. The laminograph shown in this Figure comprises an X-ray data collection device 310 and a central control unit 400. X-ray data collection device 410 has an X-ray tube 301, an X-ray data collection part 401, which includes X-ray detection sensors, a mechanism part 305 which moves a subject 403, an X-ray control part 311 which controls X-ray tube 301, a mechanism control part 322 which controls mechanism part 305, a half-mirror 304 fitted in the X-ray route between X-ray tube 301 and X-ray data collection part 401, and a television camera 302 which photographs the images of the subject reflected in half-mirror 304.

Central control unit 400 has a CPU 402 which controls all operations, an external memory unit 403 which stores various data, a bus interface 404 connected to CPU 402 via a system bus 412. Between an image bus 414 connected to system bus 412 and an I/O bus 413 connected to bus interface 404, I/Os 501 and 405, a data I/O 406, an image memory 407, an addition and averaging part 408, an image processing part 409, a display interface 410 including an image memory, an image enlargement/reduction device 420, a wipe processing part 421, and I/Os 411 and 499. Also, a CRT display 416 is connected to display interface 410. A hard copy 419 and a pointing device 415 are also connected to CRT display 416. A CAD 417 is connected to I/O 411 and a CRT display 418 is connected to CAD 417. Also, a repair device 399 is connected to I/O 499. Also, I/O 501 is connected to television camera 302, I/O 405 is connected to mechanism control device 322 and data I/O 406 is connected to X-ray data collection part 401.

Central control unit 400 accepts X-ray data from X-ray data collection device 310, and acts as a laminograph to execute image processing, such as to prepare complex images etc, using image memory 407, adding and averaging part 408, image processing part 409 and CPU 402.

Figure 44 shows the structure of repair device 399 used in the laminograph shown in Figure 43. Repair device 399, which repairs soldered parts, is composed of a PWB locating device 384, a repair information display and input device 382, a laser marker 383 and a control device 381, and is connected to central control unit 400 via control device 381 and I/O 499.

In the laminograph of this structure, while subject 303 is moved by mechanism part 305 it is penetrated by X-rays irradiated from X-ray tube 301, and during this movement radiographic images from various direction are obtained by taking these X-rays as radiographic images by X-ray data collection part 401. Mechanism part 305 has a controllable mechanism capable of moving the desired position on the surface including planes of the PWB which is the subject, so that it is possible to obtain transmission data for the position specified by CAD 417. This control is performed by mechanism control device 322.

The transmission data is taken in by image memory 407 of central control unit 400 via data I/O 406. Radiographic images, given a shift amount according to the focal plane, are prepared by addition and averaging part 408 which performs image addition and obtains a tomographic image of the desired focal plane. In this method of data collection the image obtained is a plane parallel to the direction of movement of subject 303.

Data on the PWB board, which is subject 303, and the parts mounted on the PWB board are sent to image memory 407 beforehand from CAD 417, and the size is changed by the image processing part 409 to match the size of the radiographic image determined by X-ray geometry.

The lamino image thus obtained is added with fitting the CAD pattern events to prepare a composed image. This image can be displayed on CRT 416 via display interface 410. The same image is sent to repair device 399 and can be viewed by the repair line.

Figure 45 shows the form of images displayed on the display. Figure 45(a) shows a display composed from CAD patterns and a local lamino image, Figure 45(b) shows the radiographic image and Figure 45(c) shows the lamino image. It is possible to display the desired image by specifying an icon on the CRT display with cursor 539. It is possible to show which position of the whole subject has been specified by displaying in a part of the image as a wipe image 541. The specified position 542 is characterized by changing colour.

The flow of operation is shown in the flow chart shown in Figure 46. In Figure 46, ROI is the region of interest.

Figure 47(a) is a flow chart showing the method of matching the reduced scales of the radiographic image and the CAD pattern. In this figure, first the X-ray geometry is input (Step 351) and X-ray image magnification is calculated (step 352). Methods of finding X-ray image magnification include a method in which it is found from X-ray focal point, object position and sensor position (FSD, FDD), a method in which it is found from the radiographic image of an object of previously known dimensions on the PWB, and a method in which the position of the object from the X-ray focal spot is measured by X-rays or optically. Figure 47(b) shows the X-ray geometry.

After the X-ray image magnification is calculated, the CAD pattern magnification is changed (step 353).

also possible to identify which image is being displayed by wiping and insetting the composite image to a part of the radiographic image. The coordinates of the radiographic image can be displayed at the same time. The CAD coordinates can be used as an image directory.

(4) It is possible to have a display which identifies the type of fault.

(5) The fault position and fault type of the PWB can be displayed on the PWB at the repair line.

(6) The position and nature of the repair can be confirmed at the repair line from image information on the CRT, and operation can be carried out along with the confirmation. It has also an input means which manages the ending of repairs.

(7) After repairs, the PWB is returned to the inspection line, and only the repaired part of the PWB can be re-inspected.

(8) The position of the soldering device is controlled on the basis of the information of the inspection results, and solder repairs can thus be performed automatically.

(9) The composite image can be wiped on the radiographic image for display. It is possible to display the radiographic image by distinguishing the location of the radiographic image currently displayed in the composite image.

Also, as shown by 537 in Figure 45 (a), it is possible to distinguish the fact that a PWB has passed after repair, on the area where a repaired PWB has been re-inspected and the fault had been removed and to display this on the composite image. The automatic inspection results or visual assessment results are input by pointing device 415. It is thus possible to confirm the repair results and improve the reliability of the repair line.

Also, an automatic inspection and repair device can be designed to automatically perform an X-ray inspection/repair X-ray inspection ..... loop. This is achieved by forming the loop shown as broken line in Figure 49 and thus automating the fault assessment of radiographic images and solder repairs.

As described above, according to this invention, the position of the focal plane in the subject is measured and the displacement distance is calculated on the basis of the position of the focal plane thus measured, and so it is possible to obtain with precision and certainty a tomographic image of the desired plane.

According to this invention, as the displacement distance is determined by a pattern on the radiographic image, it is possible to focus on the desired plane solely by processing the radiographic image obtained by irradiating the subject, and it is thus possible to obtain with precision and certainty a tomographic image of the desired plane.

Also, according to this invention, as laminography processes of the radiographic image are performed after enhancing, weakening or deleting characteristics of the radiographic image, it is possible to improve the S/N ratio of the lamino image, to obtain lamino images with the desired image information enhanced, and to examine lamino image groups as a small number of added images.

As described above, according to this invention, it is possible to efficiently control the inspection position of a subject with a large inspection area and to inspect this. It is also possible to supply the inspection results to a repair line and to indicate the repair position the subject. Specification of the repaired part to be re-inspected and assessment of repair results can be managed on images composed from radiographic images and CAD patterns.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

## Claims

1. A laminograph, comprising:

a radiation source for generating radiation towards a subject;

radiation surface sensor means, with a two-dimensional resolution, fitted opposite to said radiation source for detecting said radiation from said radiation source which has passed through said subject;

scanning means for moving said subject to take a plurality of different positions between said radiation source and said radiation surface sensor means and for scanning said subject in each of said different positions by said radiation from said radiation source;

data collection means for collecting said plurality of outputs of said radiation surface sensor means during said scanning by said scanning means to obtain said plurality of radiographic images of said subject in said different positions;

position measurement means for measuring multiple positions of a focal plane at multiple places of said subject;

displacement measurement means for measuring multiple displacements based on said multiple

said image processing means calculates said multiple positions in direction z by interpolating said surface measurement positions for said multiple radiographic image preparation regions, respectively, and obtains said radiographic image based on said multiple positions calculated for said multiple radiographic image preparation regions.

8. A laminograph, comprising:
a radiation source for generating radiation towards a subject;
radiation surface sensor means, with a two-dimensional resolution, fitted opposite to said radiation source for detecting said radiation from said radiation source which has passed through said subject;
scanning means for moving said subject to take a plurality of different positions between said radiation source and said radiation surface sensor means and for scanning said subject in each of said different positions by said radiation from said radiation source;
data collection means for collecting said plurality of outputs of said radiation surface sensor means during said scanning by said scanning means to obtain said plurality of radiographic images of said subject in said different positions;
position measurement means for measuring multiple positions of a focal plane at multiple places of said subject;
focusing means for moving one of said subject and a combination of said radiation source and said radiation surface sensor means so that positions to be focused coincide with a focal plane formed by said combination of said radiation source and said radiation surface sensor means based on said multiple positions on said surface of said subject measured by said position measurement means; and
image processing means for adding and averaging said plurality of radiographic images to obtain a radiographic image of said subject focused on said focal plane as a tomographic image of said subject.

9. The laminograph according to Claim 8, wherein:
said radiation surface sensor means is provided with a horizontal plane xy as a measurement surface; and
said scanning means includes movement means for moving said subject in a direction x between said radiation source and said radiation surface sensor means.

10. The laminograph according to Claim 8, wherein said scanning means includes:
means for rotating said radiation source around a single axis of rotation which is approximately normal to a measurement plane of said radiation surface sensor means; and
means for orbiting said radiation surface sensor means, in synchronism with a rotation of said radiation source, around said axis of rotation keeping an azimuth of said radiation surface sensor means constant.

11. A laminograph, comprising:
a radiation source for generating radiation towards a subject;
radiation surface sensor means, with a two-dimensional resolution, fitted opposite to said radiation source for detecting said radiation from said radiation source which has passed through said subject;
scanning means for rotating said radiation source around a single rotatory axis in an axial direction z, for orbiting said radiation surface sensor means around said rotatory axis with an 180° phase difference therefrom and synchronized with the rotation of said radiation source, while maintaining the detection plane of said radiation surface sensor means at right angles to said rotatory axis, and for scanning said subject in a plurality of different positions by said radiation from said radiation source;
subject locating means for setting said subject on said rotatory axis between said radiation surface sensor means and said radiation source;
data collection means for collecting said plurality of outputs of said radiation surface sensor means during said scanning by said scanning means to obtain said plurality of radiographic images of said subject in said different positions;
position measurement means for measuring multiple positions in axial direction z on said surface of said subject;
focusing means for moving said subject so that positions to be focused coincide with a focal plane formed by said radiation source and said radiation surface sensor means based on said multiple positions on said surface of said subject measured by said position measurement means; and
image processing means for adding and averaging said plurality of radiographic images to obtain a radiographic image of said subject focused on a single plane parallel to said detection plane of said sub-

radiation surface sensor means, with a two-dimensional resolution, fitted opposite to said radiation source for detecting said radiation from said radiation source which has passed through said subject;

scanning means for moving said subject to take a plurality of different positions between said radiation source and said radiation surface sensor means and for scanning said subject in each of said different positions by said radiation from said radiation source;

data collection means for collecting said plurality of outputs of said radiation surface sensor means during said scanning by said scanning means to obtain said plurality of radiographic images of said subject in said different positions;

image pre-processing means for processing one of enhancing, weakening and deleteing characteristics of said radiographic images to obtain pre-processed radiographic images; and

laminograph image restoration means for restoring a tomographic image of a desired plane from said pre-processed radiographic images and an information for a transmission direction of said radiation;

whereby to improve the S/N ratio of said tomographic image.

**22.** The laminograph according to Claim 21, wherein:

said image pre-processing means includes means for performing at least one process out of image density, image shape, spacial frequency of image in a spatial frequency area, logic filtering, inter-image algorithms and morphological processing.

**23.** A laminograph, comprising:

a radiation source for generating radiation towards a subject;

radiation surface sensor means, with a two-dimensional resolution, fitted opposite to said radiation source for detecting said radiation from said radiation source which has passed through said subject;

scanning means for moving said subject to take a plurality of different positions between said radiation source and said radiation surface sensor means and for scanning said subject in each of said different positions by said radiation from said radiation source;

data collection means for collecting said plurality of outputs of said radiation surface sensor means during said scanning by said scanning means to obtain said plurality of radiographic images of said subject in said different positions;

laminograph image restoration means for restoring a tomographic image of a desired plane from said radiographic images and an information for a transmission direction of said radiation as a tomographic image of said subject; and

specific point detection means for detecting images linked in the same direction as the direction for changing said transmission direction to generate a specific point detection signal.

**24.** The laminograph according to Claim 23, further comprising:

image pre-processing means for processing one of enhancing, weakening and deleteing characteristics of said radiographic images at said specific point thus detected to obtain pre-processed radiographic images; and

wherein said laminograph image restoration means restores said tomographic image of said desired plane from said pre-processed radiographic images and said information for said transmission direction of said radiation.

**25.** A laminograph, comprising:

a radiation source for generating radiation towards a subject;

radiation surface sensor means, with a two-dimensional resolution, fitted opposite to said radiation source for detecting said radiation from said radiation source which has passed through said subject;

scanning means for moving said subject to take a plurality of different positions between said radiation source and said radiation surface sensor means and for scanning said subject in each of said different positions by said radiation from said radiation source;

data collection means for collecting said plurality of outputs of said radiation surface sensor means during said scanning by said scanning means to obtain said plurality of radiographic images of said subject in said different positions; and

laminograph image restoration means for restoring tomographic images of desired planes from said radiographic images and an information for a transmission direction of said radiation, and for adding said tomographic images thus obtained to produce a composite lamino image.

**26.** The laminograph according to Claim 25, wherein:

33. The laminograph according to Claim 30, further comprising:
information presentation means for presentating an information concerning a shape of said subject, positions of constituent parts of said subject, and locations to be inspected;
whereby said radiographic image being obtained at a position of said subject specified by said information.

34. An inspection and repair device, comprising:
a laminograph including,
a radiation source for generating radiation towards a subject,
radiation detection means with a two-dimensional detection area positioned opposite said radiation source for detecting said radiation from said radiation source which has passed through said subject to obtain a radiographic image,
movement means for moving said subject so as to obtain said radiographic images of said subject from many directions,
laminograph image restoration means for restoring a tomographic image of a desired plane from said radiographic images and an information for a transmission direction of said radiation,
image magnification and reduction means for changing a magnification of at least one of said radiographic image and said tomographic image and for changing a magnification of a pattern showing a shape of said subject,
composite image preparation means for preparing a composite image composed of said pattern showing said shape of said subject with a changed magnification and one of said radiographic image and said tomographic image with a changed magnification in the same scale, and
display means for displaying said composite image and at least one of said radiographic image and said tomographic image;
communication and control means for communicating an inspection result, said images and a repair result to said laminograph and for controlling said inspection result and said repair result;
display input means for displaying said inspection result and said images and for inputting said repair result; and
means for returning said subject repaired to an inspection process to re-inspect an part which has been repaired of said subject.

35. The inspection and repair device according to Claim 34, further comprising:
locating means for locating said subject in a specified position;
position display means for optically charcterising said specified position on said subject; and
control means for controlling said locating means and said position display means, whereby to display a fault position of said subject repaired on said composite image on said subject repaired.

36. The inspection and repair device according to Claim 35:
wherein said position display means changes its optical characteristic according to a type of fault and displays said characteristic on said subject.

37. The inspection and repair device according to Claim 34, further comprising:
information presentation means for presentating an information concerning a shape of said subject, positions of constituent parts of said subject, and locations to be inspected;
whereby said radiographic image being obtained at a position of said subject specified by said information.

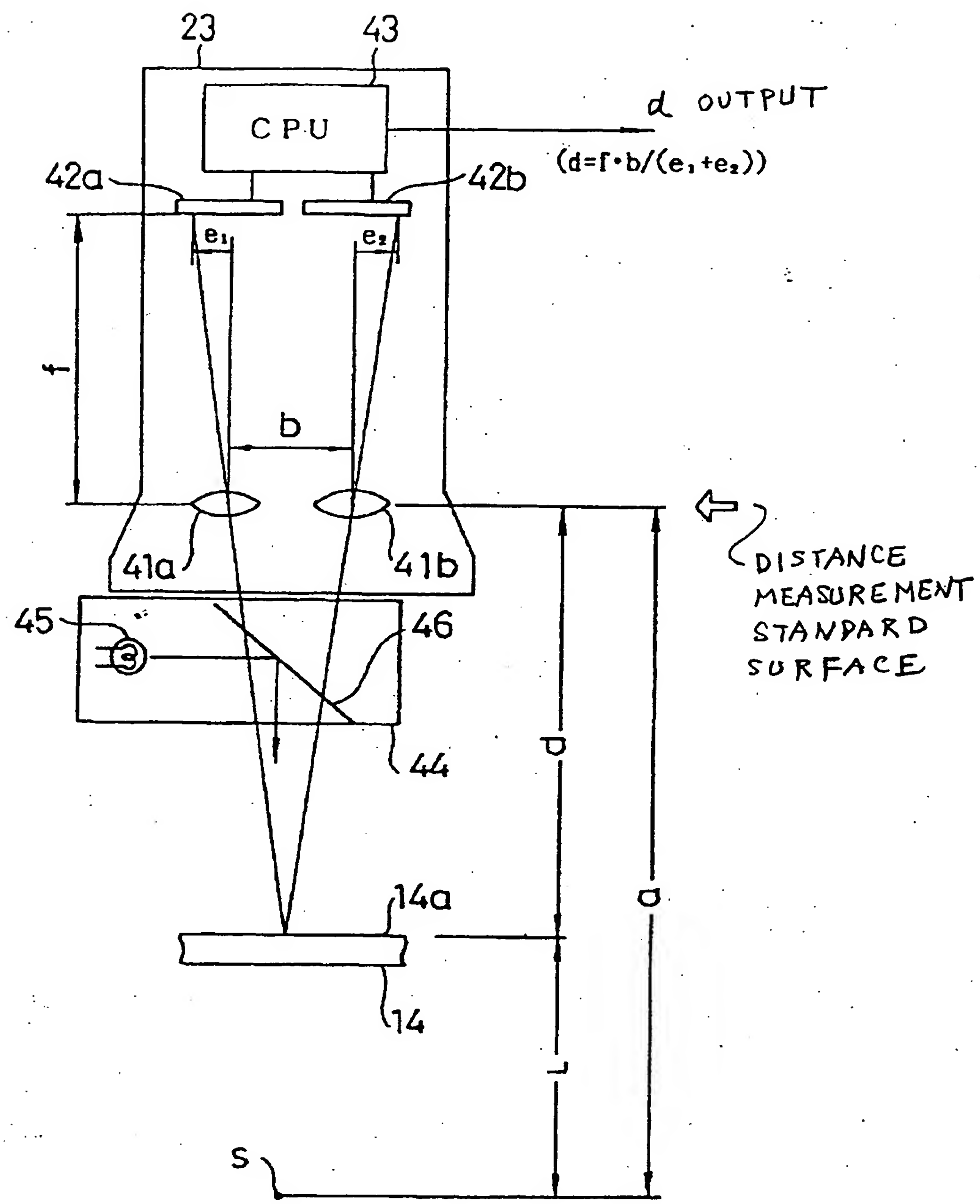
23
43
CPU
d OUTPUT
(d=f·b/(e1+e2))
42a
42b
e1
e2
f
b
41a
41b
DISTANCE
MEASUREMENT
STANDARD
SURFACE
45
46
44
D
a
14a
14
L
S

FIG. 2

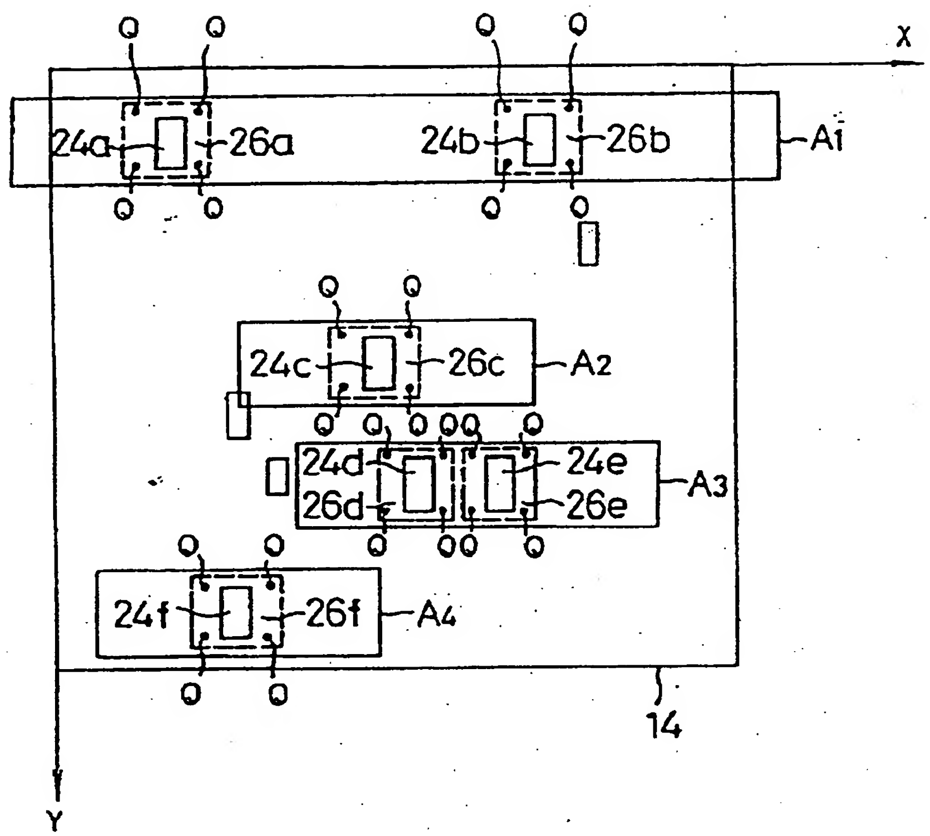


FIG. 4

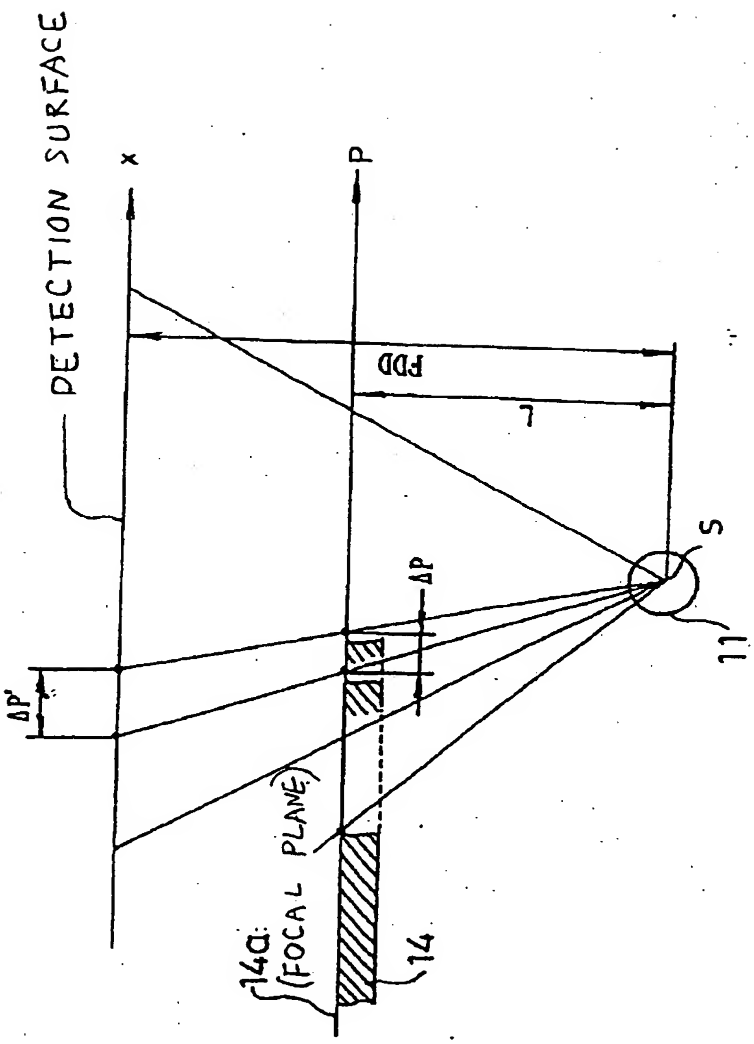


FIG. 6

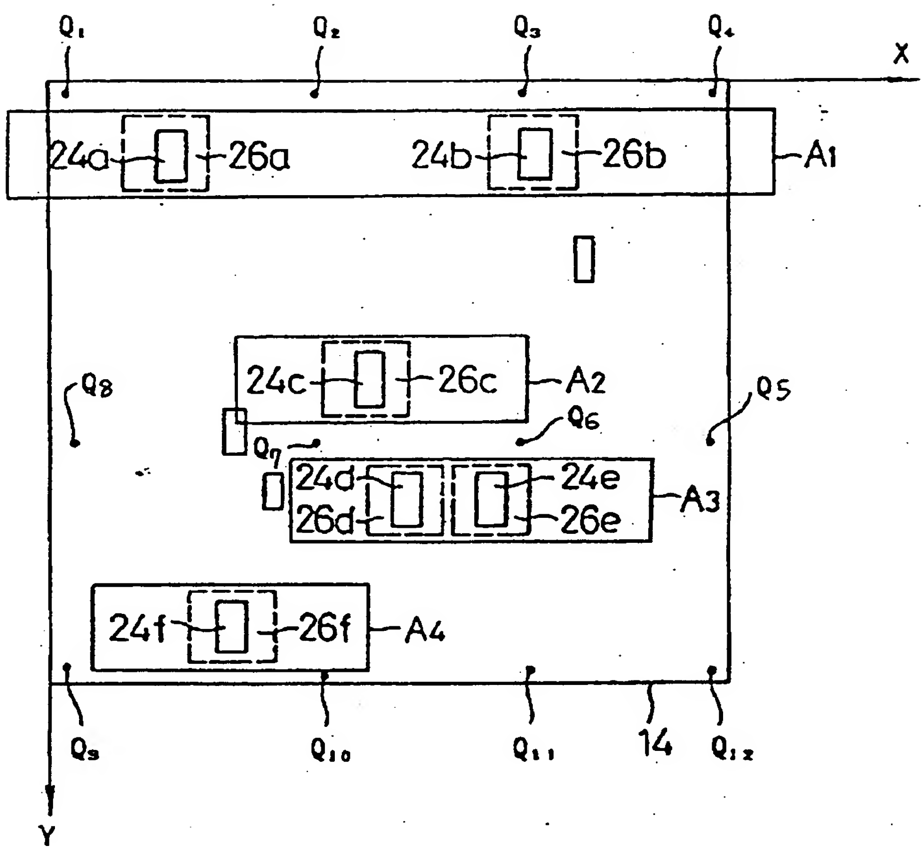
Q1
Q2
Q3
Q4
X
24a
26a
24b
26b
A1
24c
26c
A2
Q8
Q5
Q6
Q7
24d
26d
24e
26e
A3
24f
26f
A4
Q9
Q10
Q11
14
Q12
Y

FIG. 8

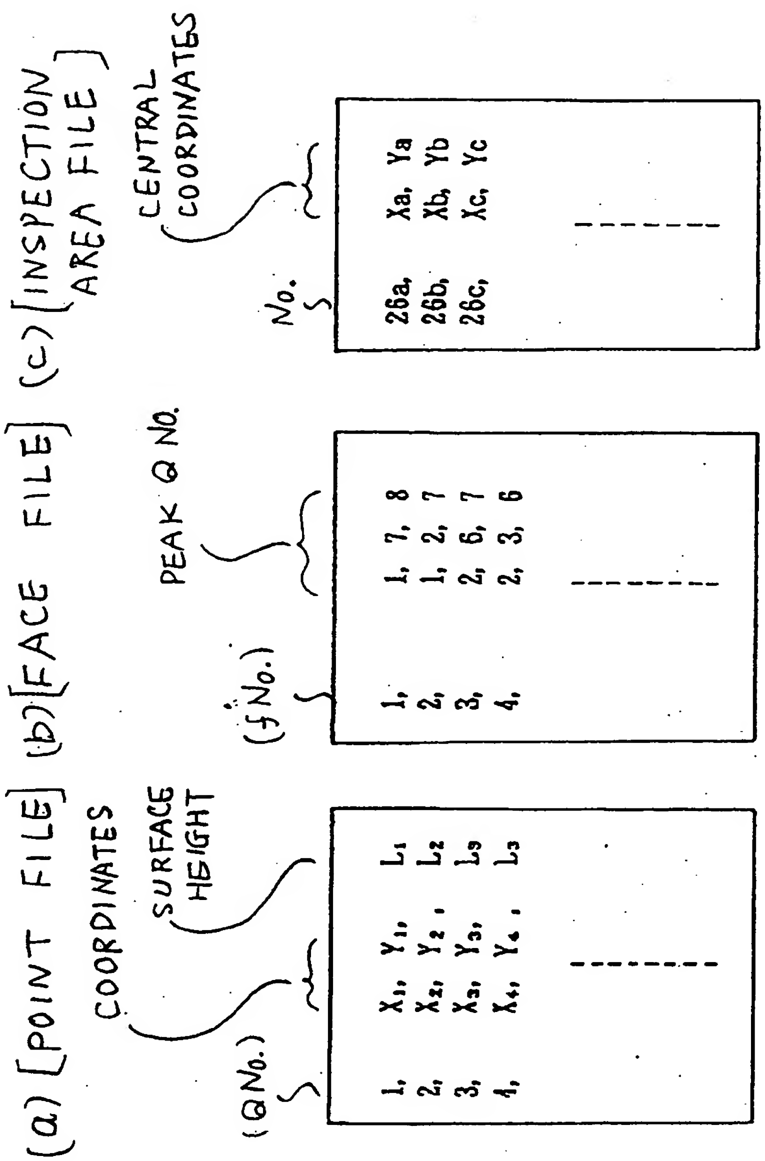
(a) [POINT FILE]
(QNo.)
COORDINATES
SURFACE HEIGHT
1, X1, Y1, L1
2, X2, Y2, L2
3, X3, Y3, L3
4, X4, Y4, L3
(b) [FACE FILE]
(f No.)
PEAK Q No.
1, 1, 7, 8
2, 1, 2, 7
3, 2, 6, 7
4, 2, 3, 6
(c) [INSPECTION AREA FILE]
No.
CENTRAL COORDINATES
26a, Xa, Ya
26b, Xb, Yb
26c, Xc, Yc

FIG. 10

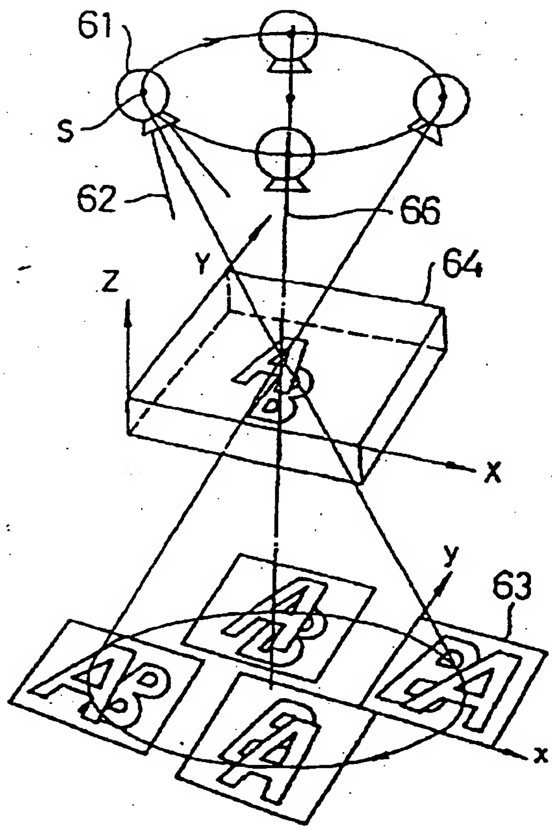


FIG. 12

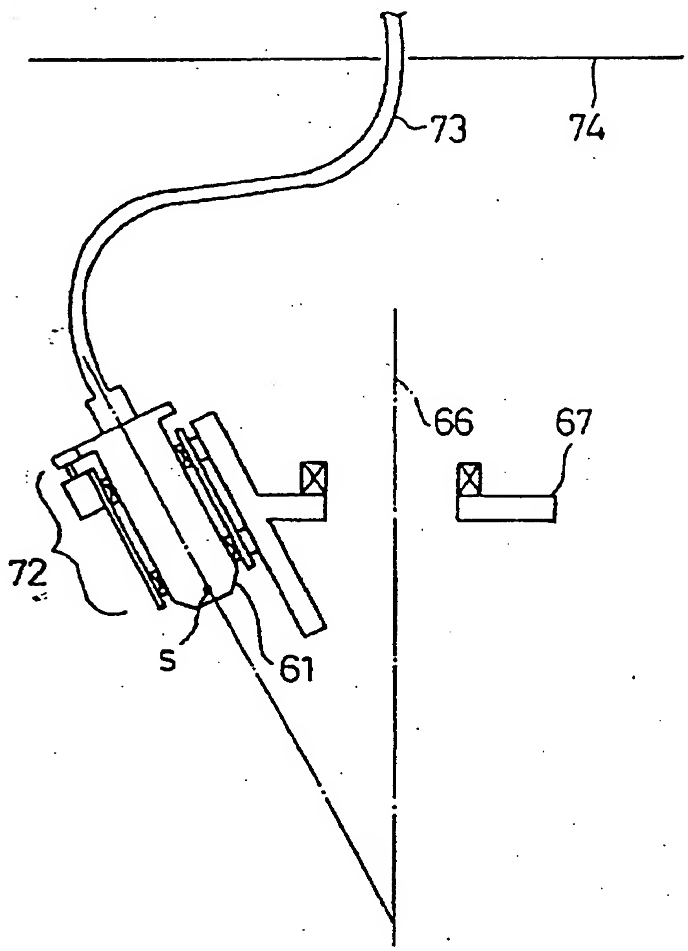


FIG. 14

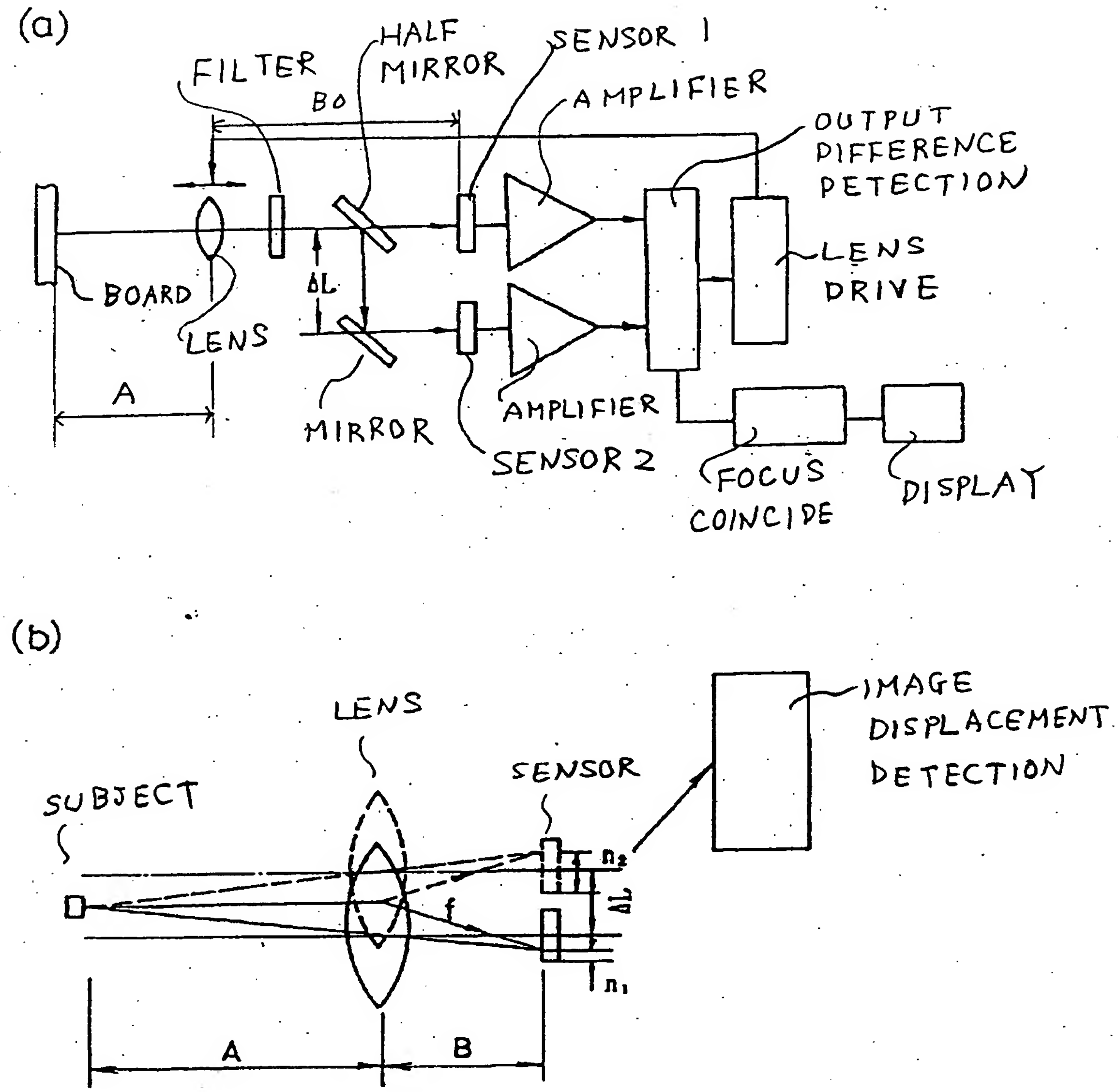
(a)
FILTER
HALF MIRROR
SENSOR 1
AMPLIFIER
Bo
OUTPUT DIFFERENCE DETECTION
LENS DRIVE
BOARD
LENS
ΔL
A
MIRROR
AMPLIFIER
SENSOR 2
FOCUS COINCIDE
DISPLAY
(b)
LENS
SENSOR
IMAGE DISPLACEMENT DETECTION
SUBJECT
n2
ΔL
f
n1
A
B

FIG. 17

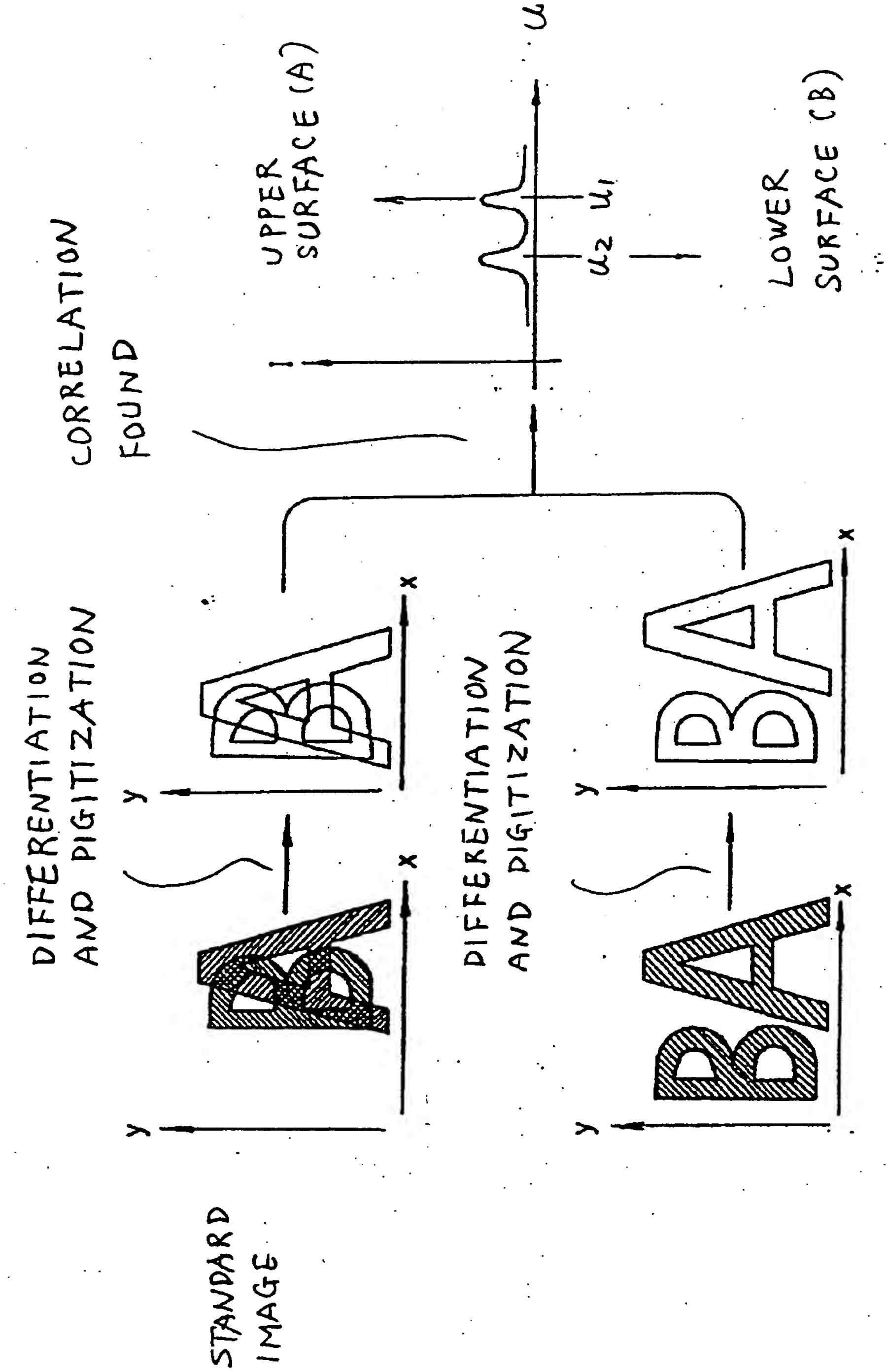
STANDARD IMAGE
DIFFERENTIATION AND DIGITIZATION
DIFFERENTIATION AND DIGITIZATION
CORRELATION FOUND
UPPER SURFACE (A)
LOWER SURFACE (B)
u
$u_1$
$u_2$
x
y

FIG. 19

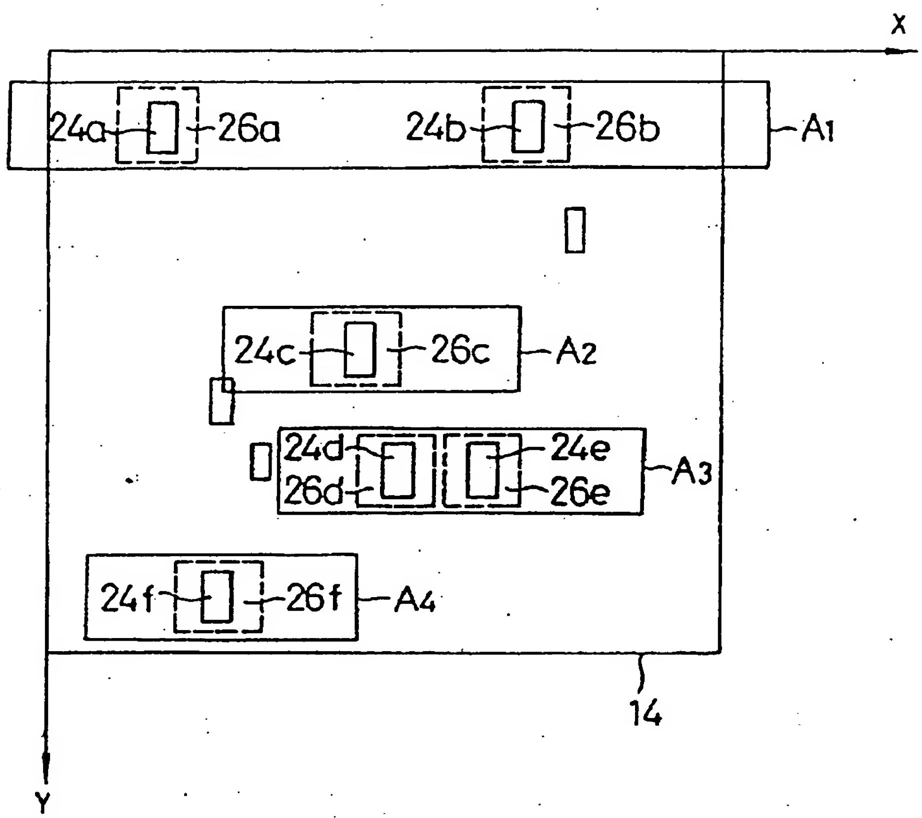


FIG. 21

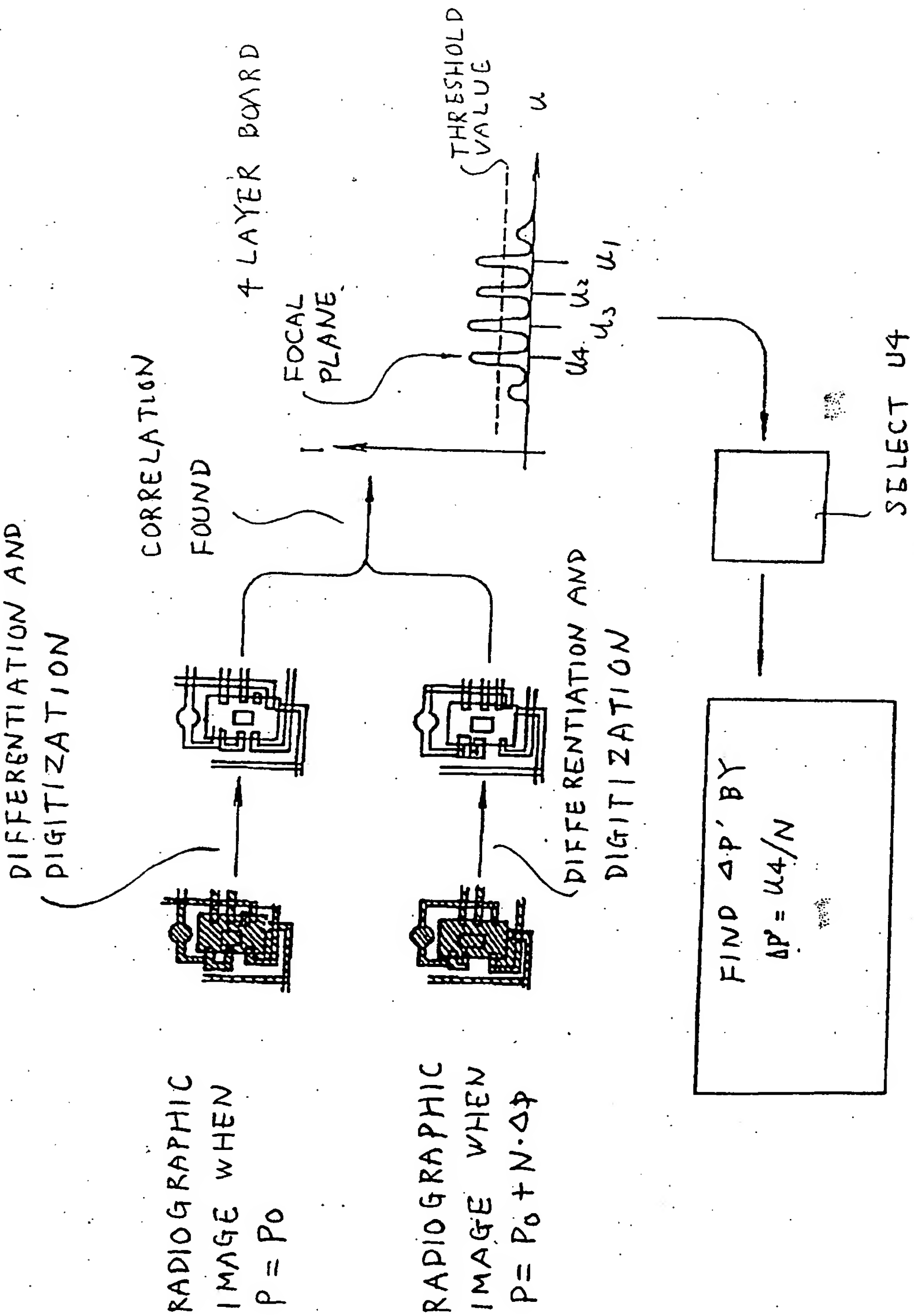
RADIOGRAPHIC IMAGE WHEN P = Po
DIFFERENTIATION AND DIGITIZATION
RADIOGRAPHIC IMAGE WHEN P= Po+N·Δp
DIFFERENTIATION AND DIGITIZATION
CORRELATION FOUND
4 LAYER BOARD
FOCAL PLANE
THRESHOLD VALUE
u
u4
u3
u2
u1
SELECT U4
FIND ΔP' BY
ΔP' = U4/N

FIG. 23

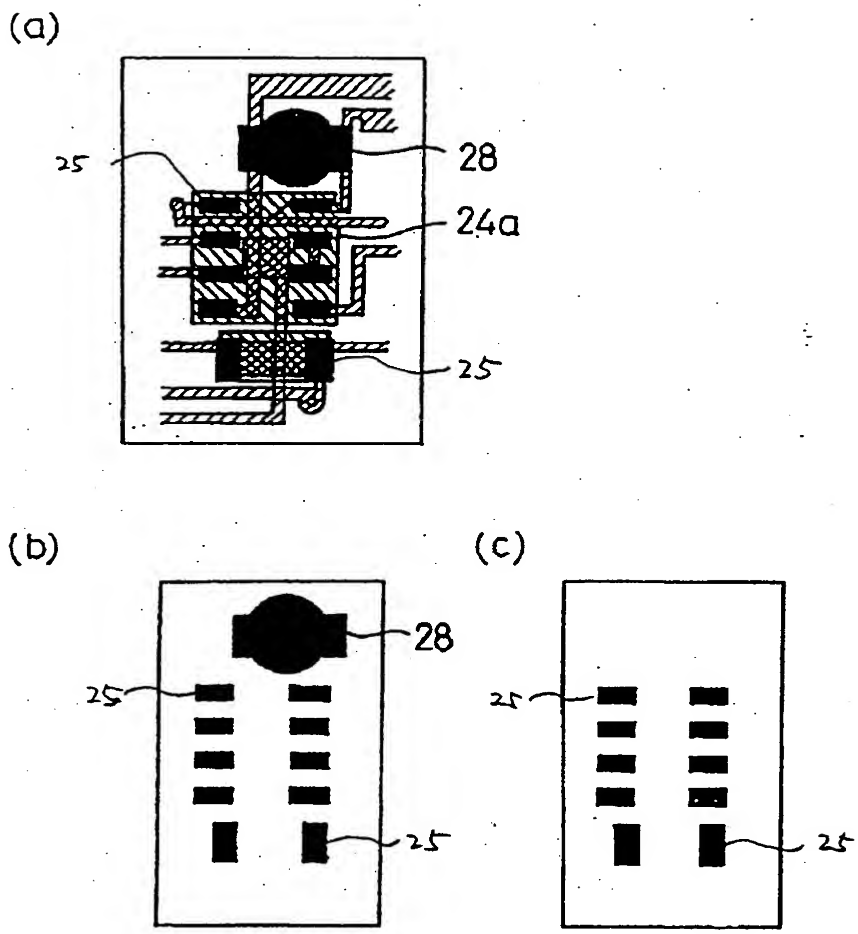


FIG. 25

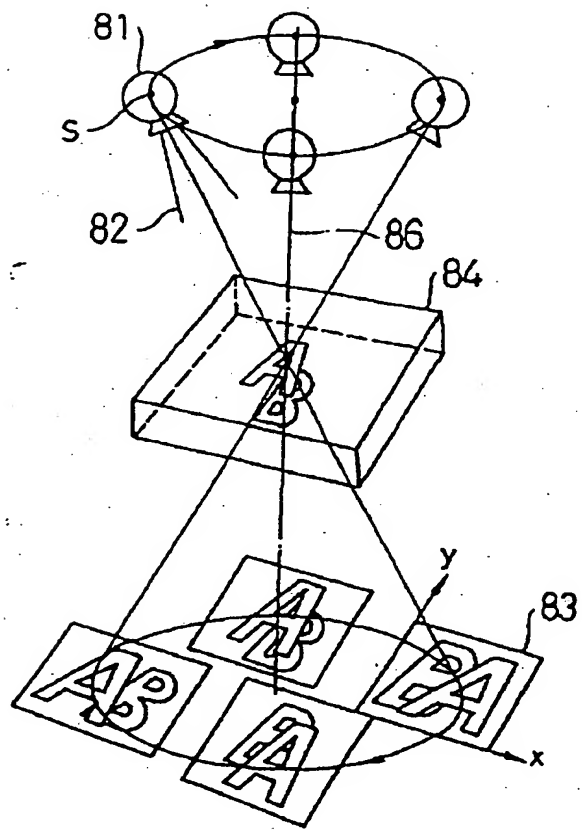


FIG. 27

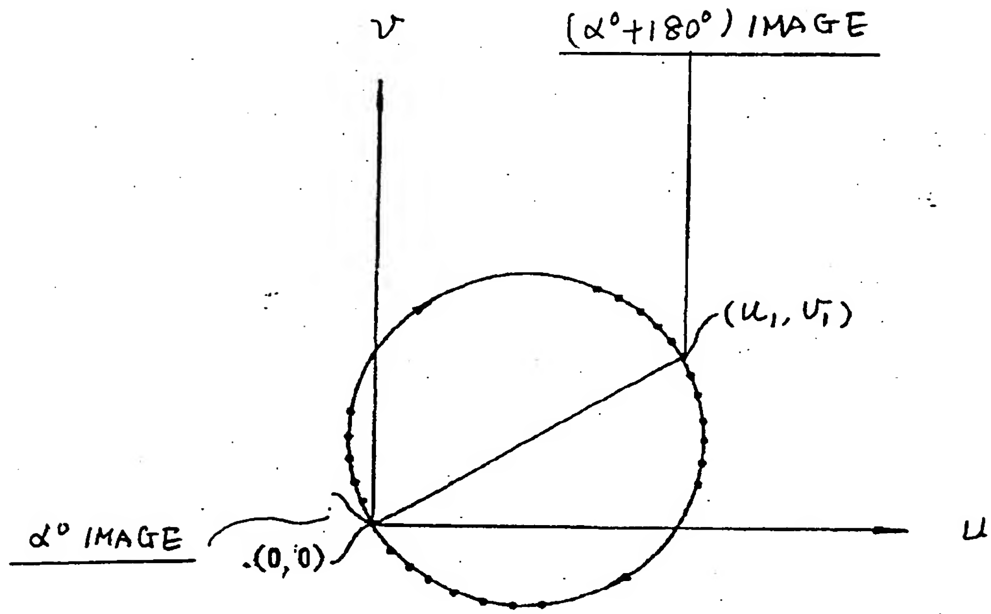


FIG. 29

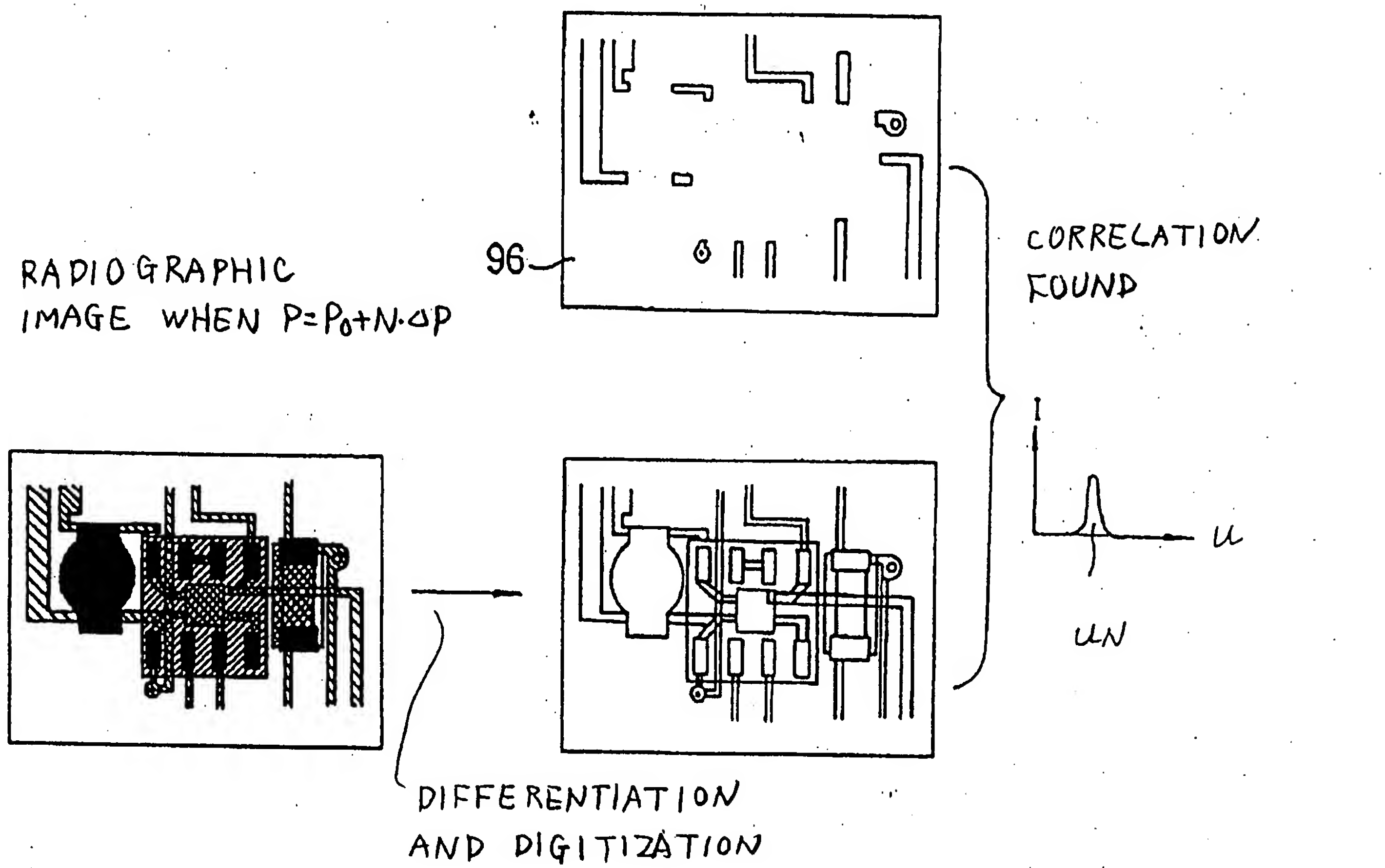
RADIOGRAPHIC
IMAGE WHEN P=P0+N·ΔP
96
CORRELATION
FOUND
I
u
uN
DIFFERENTIATION
AND DIGITIZATION

FIG. 31

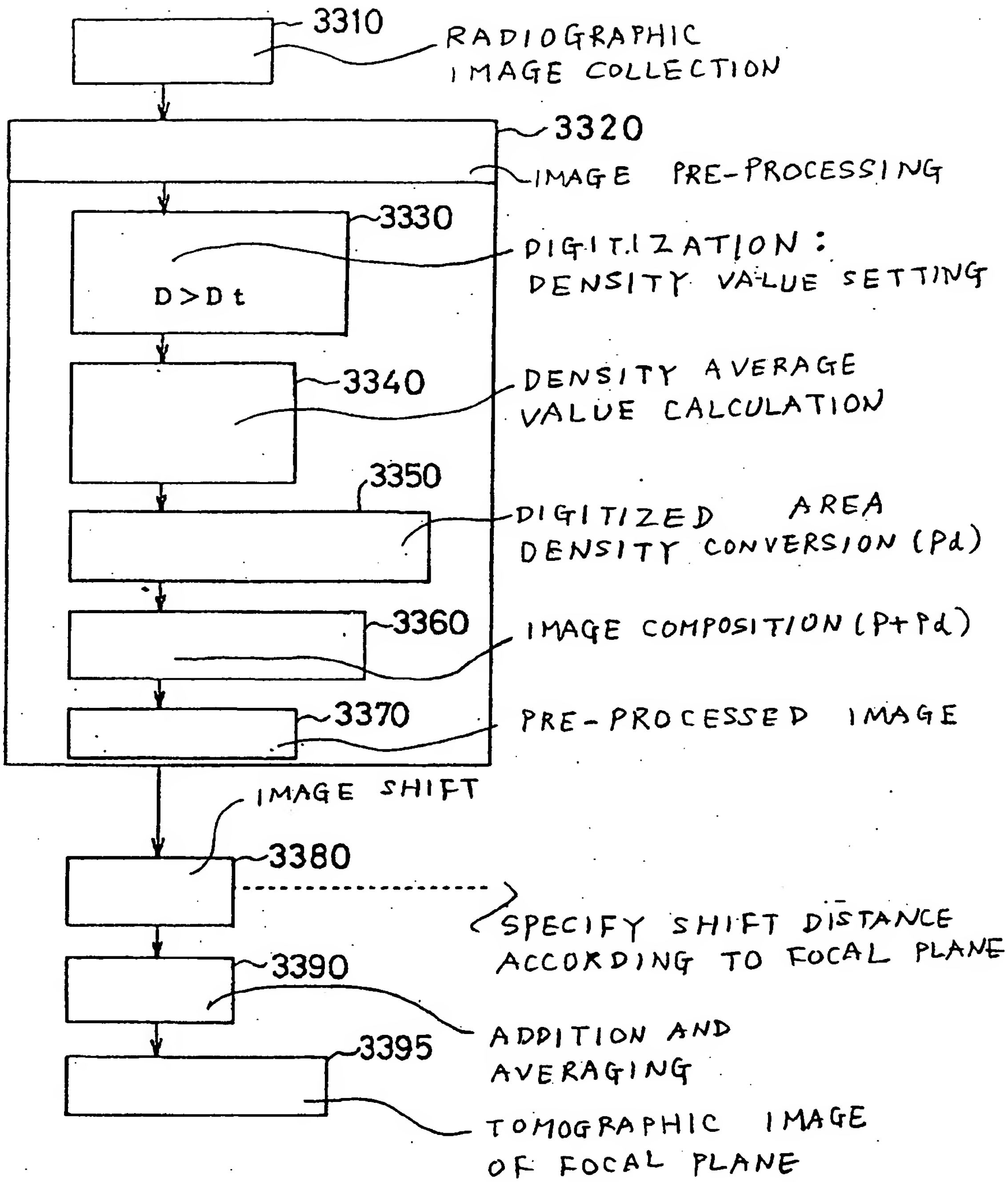
3310
RADIOGRAPHIC IMAGE COLLECTION
3320
IMAGE PRE-PROCESSING
3330
D>Dt
DIGITIZATION: DENSITY VALUE SETTING
3340
DENSITY AVERAGE VALUE CALCULATION
3350
DIGITIZED AREA DENSITY CONVERSION (Pd)
3360
IMAGE COMPOSITION (P+Pd)
3370
PRE-PROCESSED IMAGE
IMAGE SHIFT
3380
SPECIFY SHIFT DISTANCE ACCORDING TO FOCAL PLANE
3390
ADDITION AND AVERAGING
3395
TOMOGRAPHIC IMAGE OF FOCAL PLANE

FIG. 33

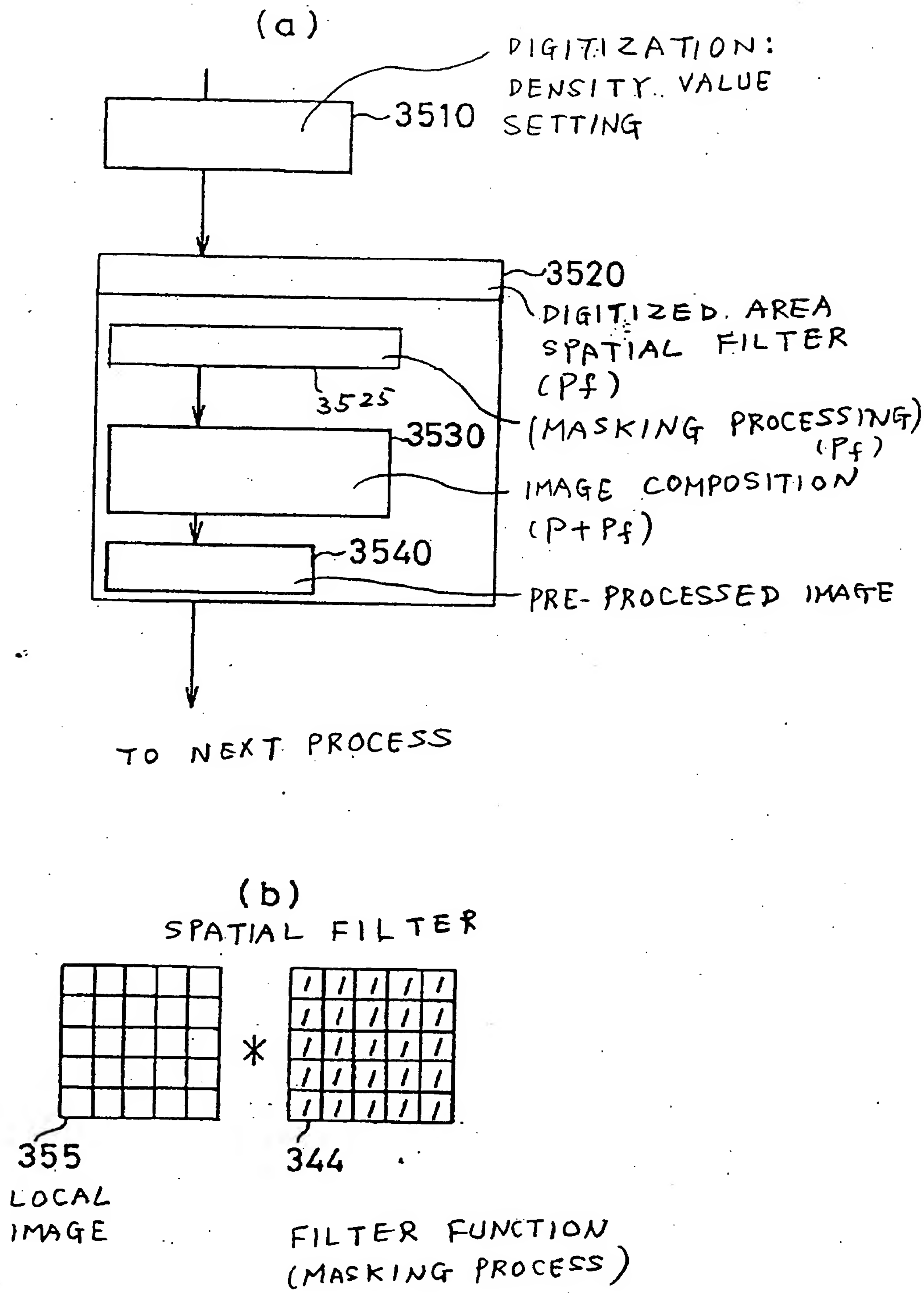
(a)
DIGITIZATION: DENSITY VALUE SETTING
3510
3520
DIGITIZED AREA SPATIAL FILTER (Pf)
3525
3530
(MASKING PROCESSING) (Pf)
IMAGE COMPOSITION (P+Pf)
3540
PRE-PROCESSED IMAGE
TO NEXT PROCESS
(b)
SPATIAL FILTER
*
355
LOCAL IMAGE
344
FILTER FUNCTION (MASKING PROCESS)

FIG. 35

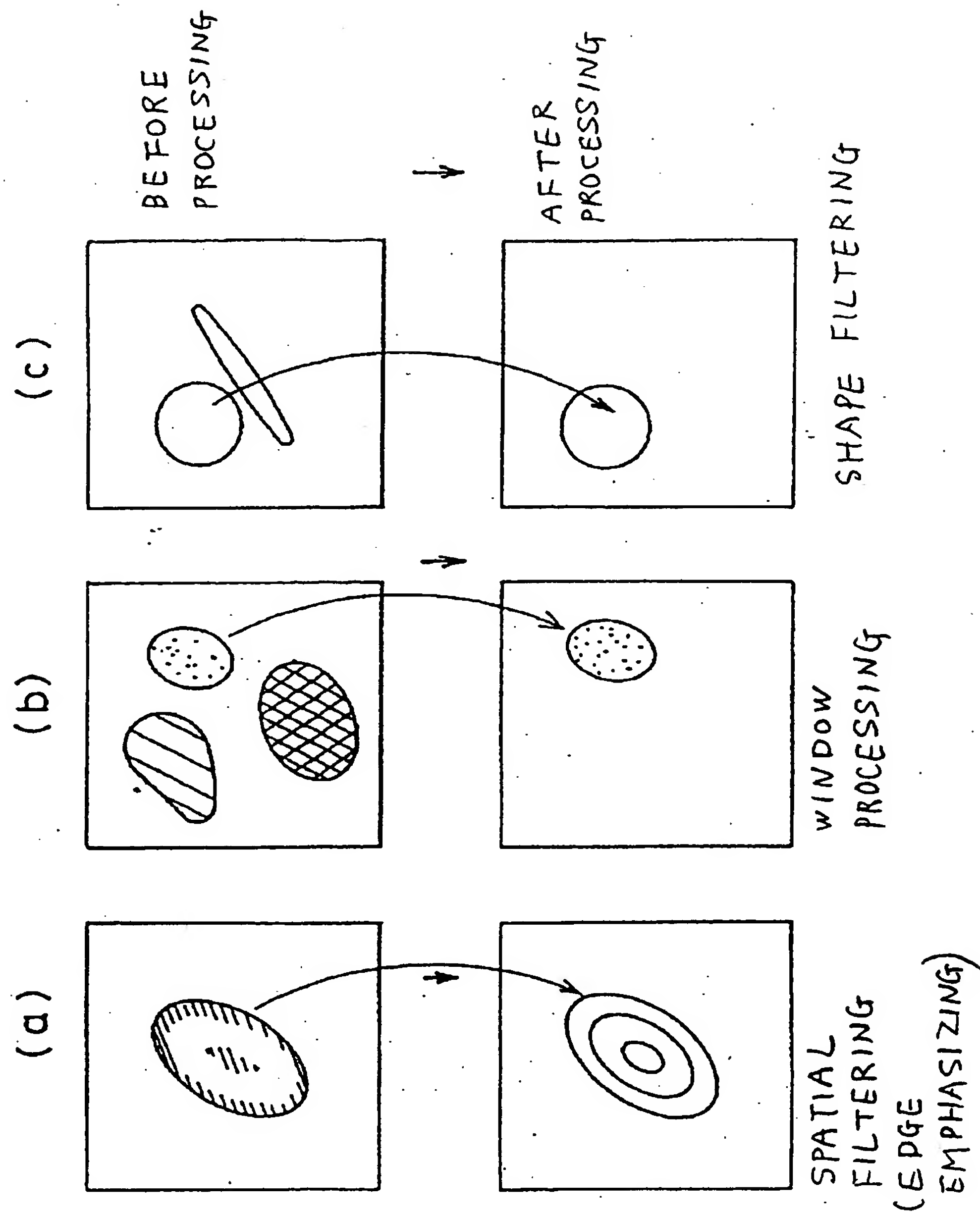
(a)
(b)
(c)
BEFORE PROCESSING
AFTER PROCESSING
SPATIAL FILTERING (EDGE EMPHASIZING)
WINDOW PROCESSING
SHAPE FILTERING

FIG. 37

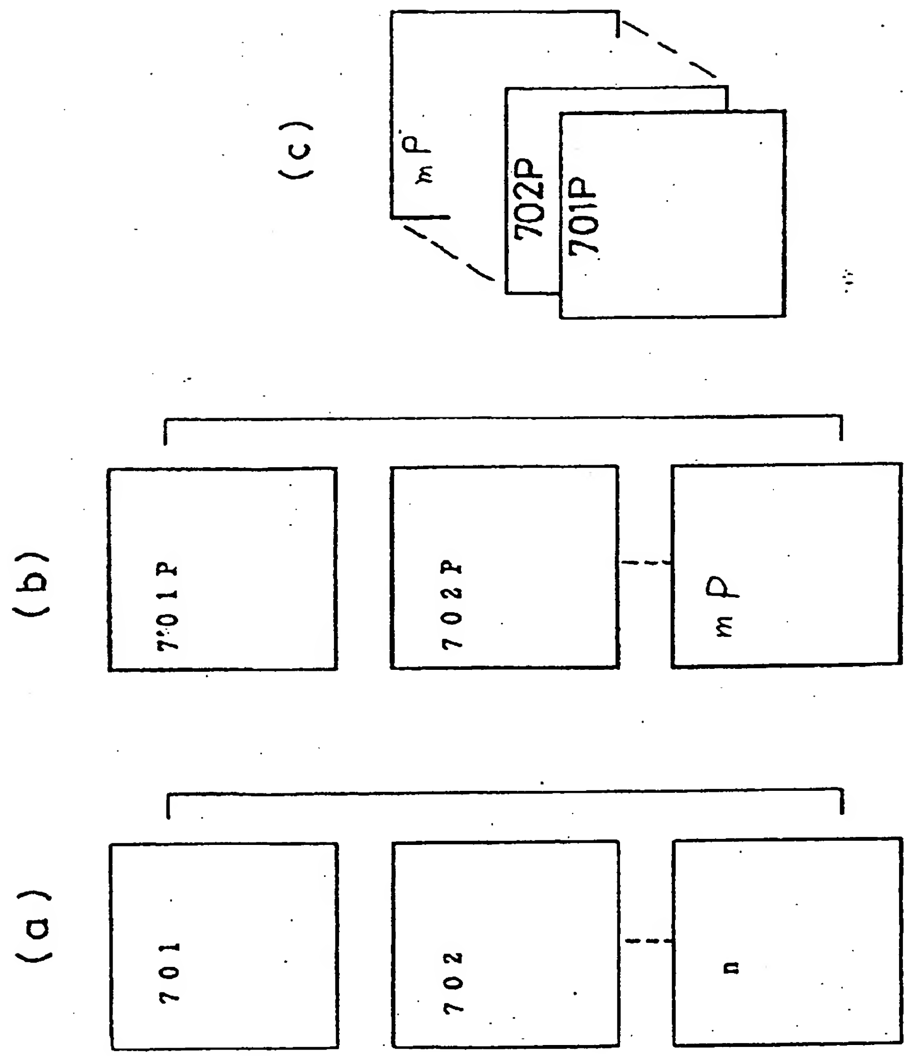


FIG. 40

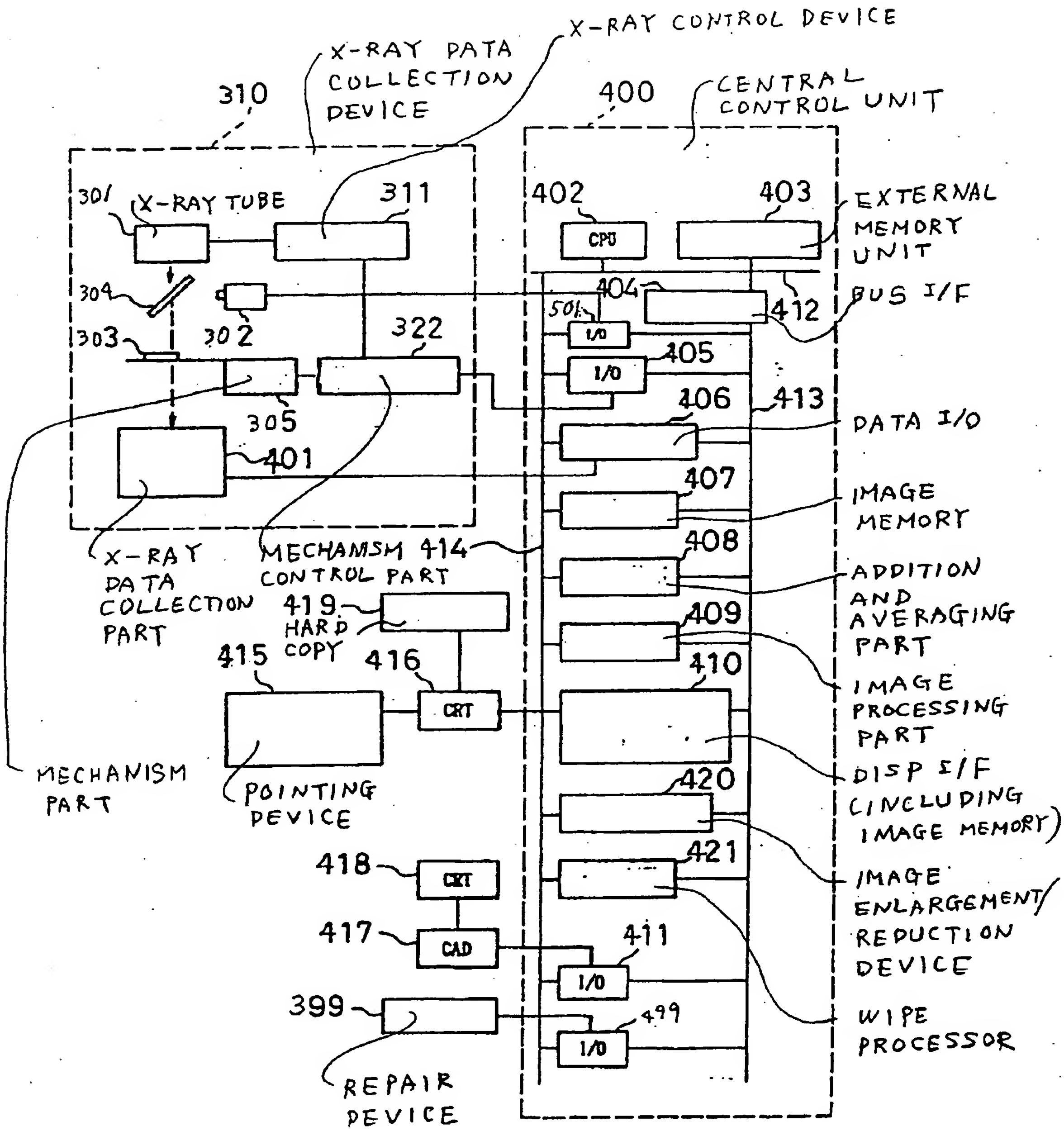
X-RAY CONTROL DEVICE
X-RAY DATA COLLECTION DEVICE
310
400
CENTRAL CONTROL UNIT
301
X-RAY TUBE
311
402
403
CPU
EXTERNAL MEMORY UNIT
304
404
412
BUS I/F
501
I/O
302
322
303
405
I/O
406
413
305
DATA I/O
401
407
IMAGE MEMORY
408
X-RAY DATA COLLECTION PART
MECHANISM CONTROL PART
414
ADDITION AND AVERAGING PART
419
HARD COPY
409
415
416
410
IMAGE PROCESSING PART
CRT
DISP I/F (INCLUDING IMAGE MEMORY)
MECHANISM PART
POINTING DEVICE
420
418
CRT
421
IMAGE ENLARGEMENT/ REDUCTION DEVICE
417
CAD
411
I/O
399
499
WIPE PROCESSOR
I/O
REPAIR DEVICE

FIG. 43

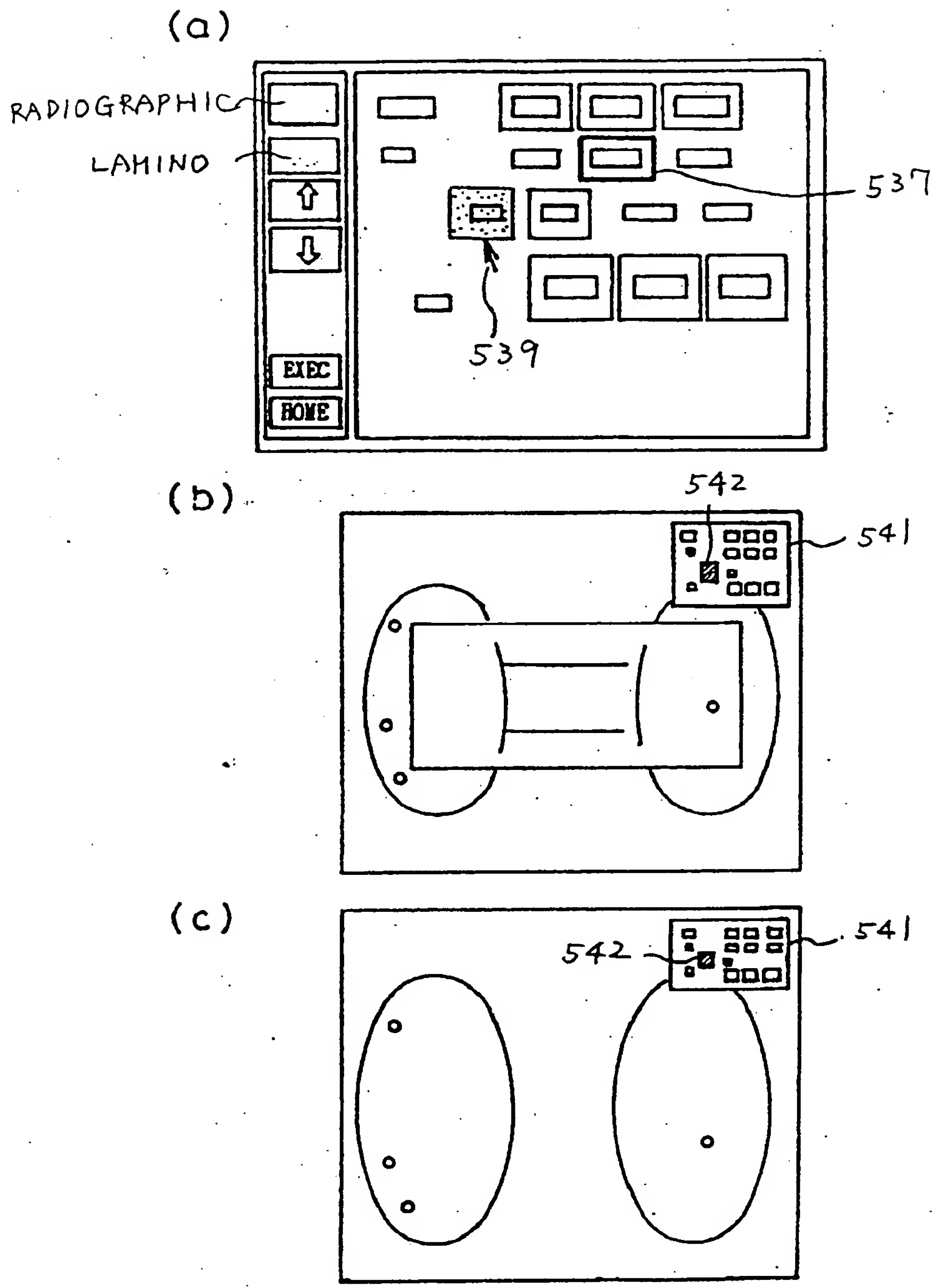


FIG. 45

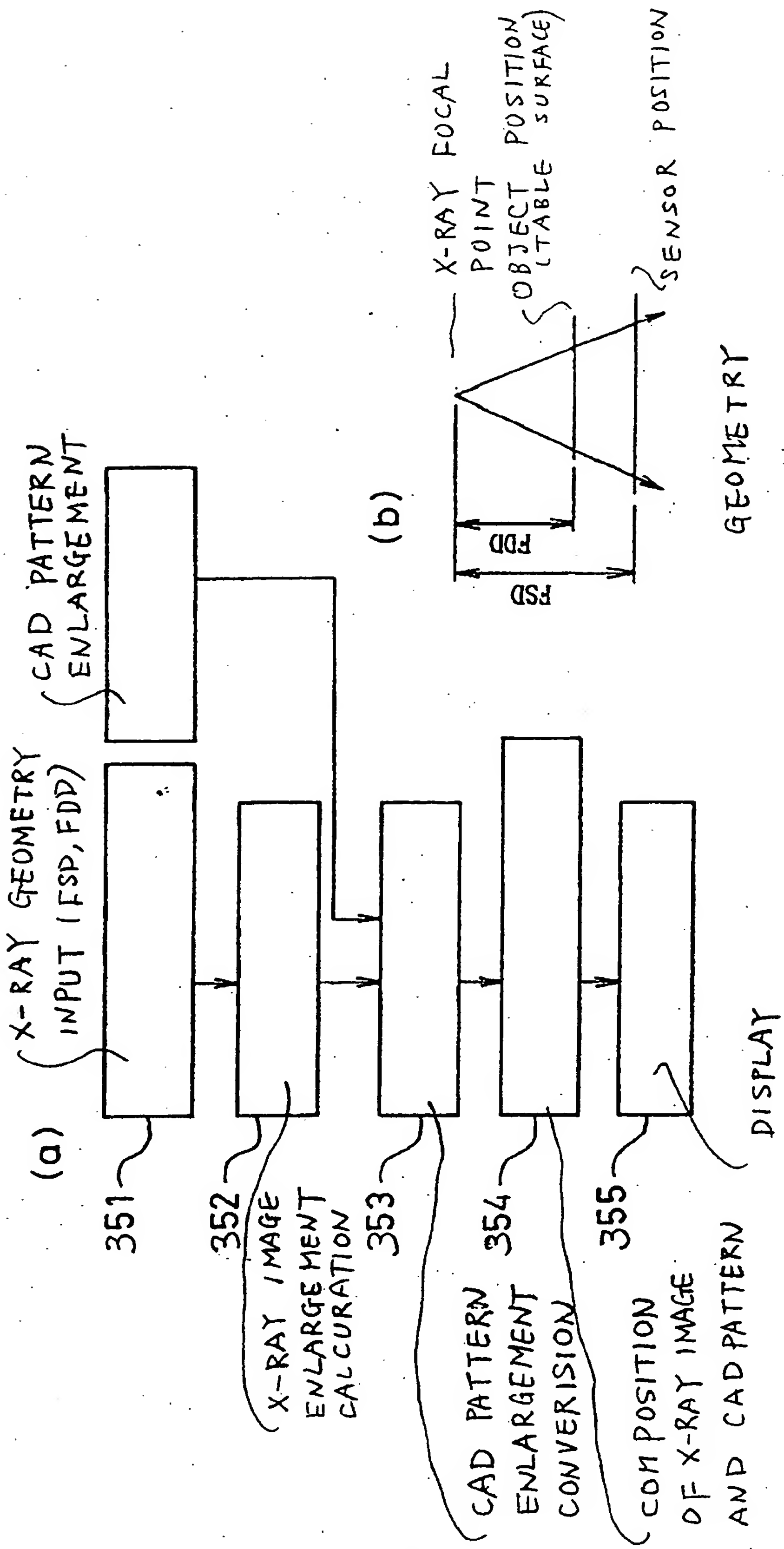
(a)
X-RAY GEOMETRY INPUT (FSP, FDD)
CAD PATTERN ENLARGEMENT
351
352
X-RAY IMAGE ENLARGEMENT CALCURATION
353
CAD PATTERN ENLARGEMENT CONVERISION
354
COMPOSITION OF X-RAY IMAGE AND CAD PATTERN
355
DISPLAY
(b)
X-RAY FOCAL POINT
OBJECT POSITION (TABLE SURFACE)
SENSOR POSITION
FDD
FSD
GEOMETRY

FIG. 47

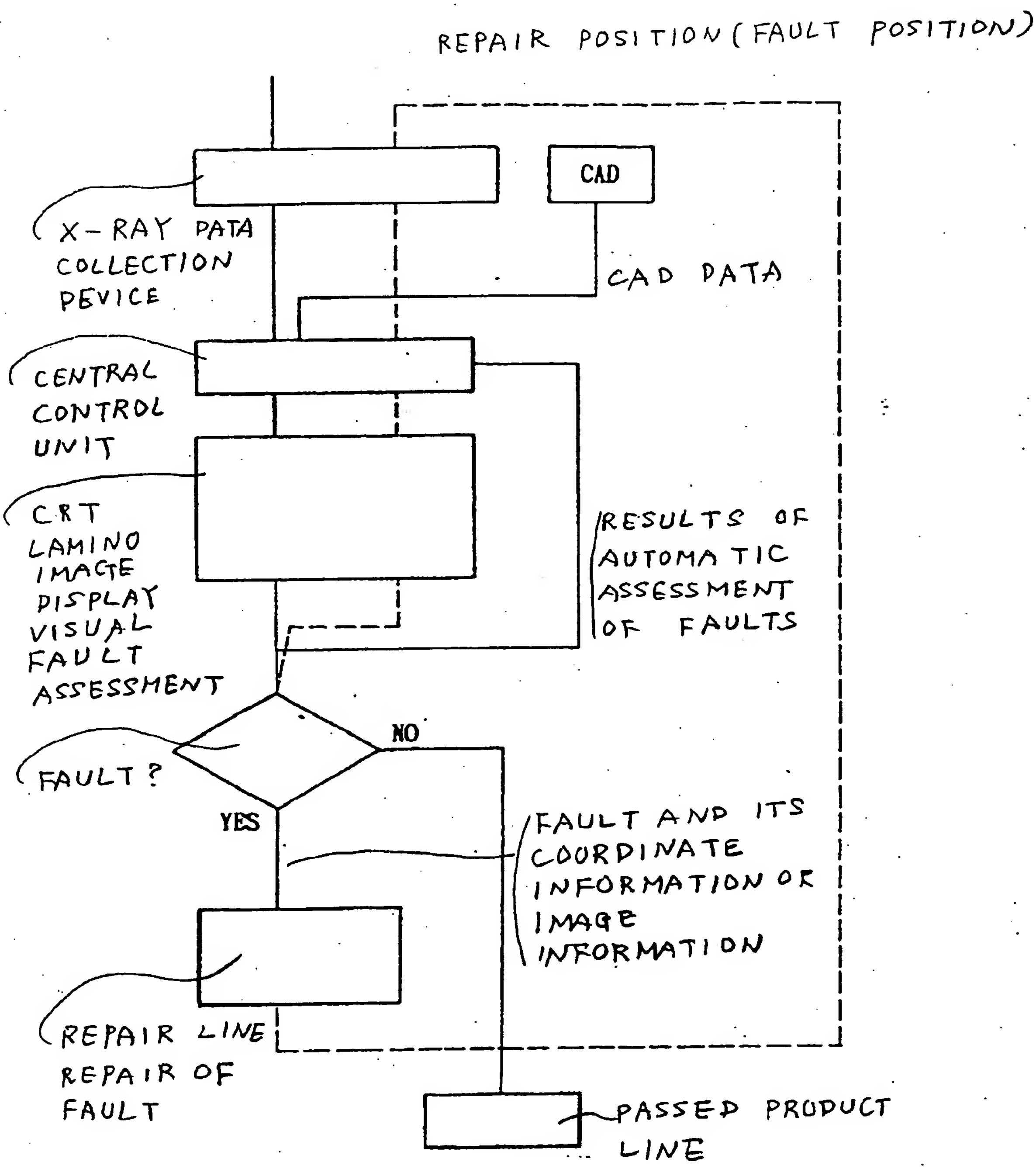
REPAIR POSITION (FAULT POSITION)
CAD
X-RAY DATA COLLECTION DEVICE
CAD DATA
CENTRAL CONTROL UNIT
CRT LAMINO IMAGE DISPLAY VISUAL FAULT ASSESSMENT
RESULTS OF AUTOMATIC ASSESSMENT OF FAULTS
FAULT ?
NO
YES
FAULT AND ITS COORDINATE INFORMATION OR IMAGE INFORMATION
REPAIR LINE REPAIR OF FAULT
PASSED PRODUCT LINE

FIG. 49

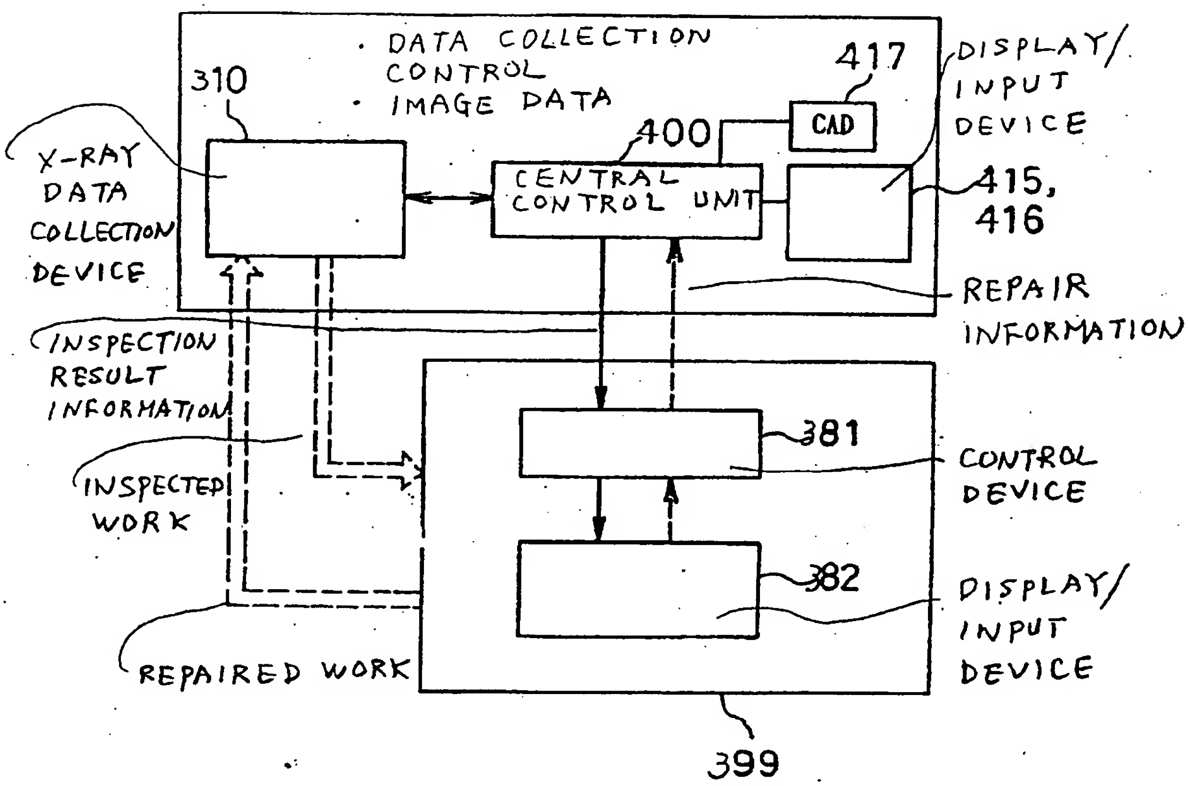
DATA COLLECTION CONTROL
IMAGE DATA
310
417
CAD
400
DISPLAY/ INPUT DEVICE
X-RAY DATA COLLECTION DEVICE
CENTRAL CONTROL UNIT
415, 416
REPAIR INFORMATION
INSPECTION RESULT INFORMATION
381
CONTROL DEVICE
INSPECTED WORK
382
DISPLAY/ INPUT DEVICE
REPAIRED WORK
399

FIG. 51

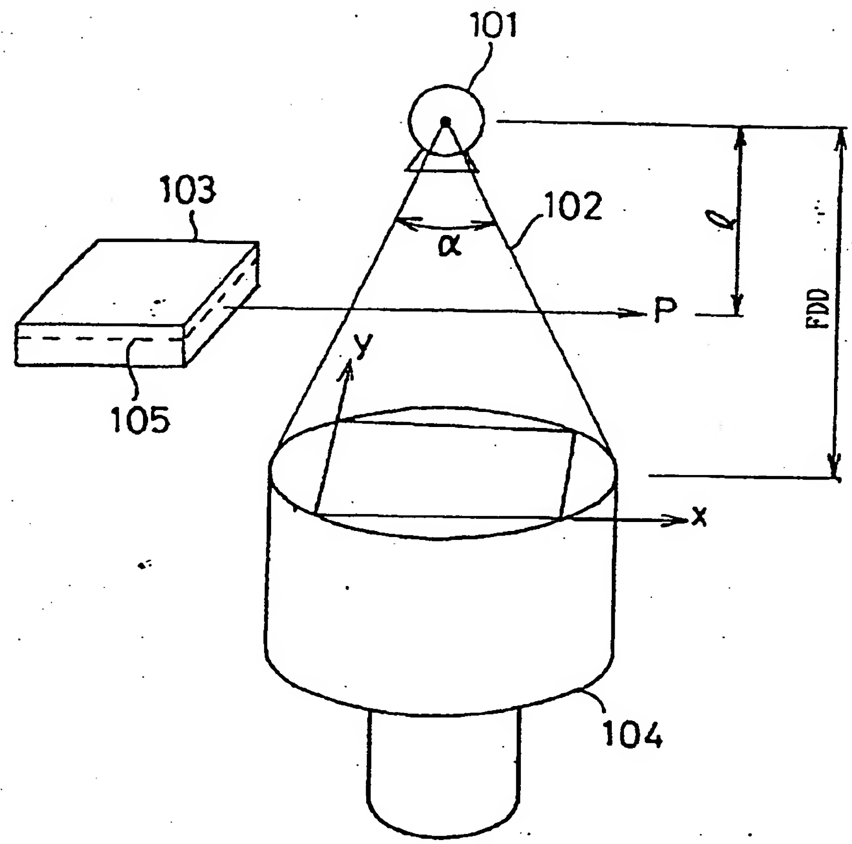


FIG. 53 (PRIOR ART)

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 95 30 3194

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
|---|---|---|---|
| X | WO-A-89 04477 (FOUR PI SYSTEMS) | 16,21, 23,25,30 | G01N23/04 H05K13/08 |
| | * page 7, line 5 - page 8, line 17 * | | |
| | * page 9, line 32 - page 10, line 11 * | | |
| A | * page 16, line 10 - page 17, line 8 * | | |
| | * page 25, line 15 - page 26, line 3 * | | |
| | * page 49, line 8 - line 27 * | | |
| | * page 50, line 23 - page 51, line 15 * | | |
| | * page 54, line 9 - line 31 * | | |
| Y | * page 55 - page 68; figure 3A * | 34 | |
| Y | US-A-4 667 403 (EDINGER) * abstract * * column 7, line 11 - line 26 * | 34 | |
| A | WO-A-92 04620 (FOUR PI SYSTEMS) * page 3, line 31 - line 36 * * page 15, line 37 - page 16, line 14 * * page 37, line 17 - page 46, line 14 * * figure 5 * | 1,4,8, 11,16, 21,23, 25,30,34 | TECHNICAL FIELDS SEARCHED (Int.Cl.6) G01N |
| A | EP-A-0 577 414 (IBM) * abstract * * column 2, line 32 - line 37 * * column 2, line 56 - column 3, line 9 * * column 3, line 49 - column 4, line 29 * * figures 1,3 * | 1,4,8, 11,16, 21,23, 25,30,34 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 4 September 1995 | Thomas, R.M. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)